EVALUATION OF FUEL LOADING DENSITIES AND METHODS ON WOOD STOVE EMISSIONS RATES

Prepared for

Technology Branch
Energy Mines and Resources, Canada
DDS Contract Number: 23216-8-9058/045SZ

June 1990

Prepared by

Rick Curkeet, P.E.

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95 pp

MICROMEDIA

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WARNOCK HERSEY INTERNATIONAL, INC. TEST REPORT #632-911300
FUEL LOADING DENSITY EFFECTS ON WOOD STOVE EMISSIONS RATES
PREPARED FOR: TECHNOLOGY BRANCH, ENERGY MINES AND RESOURCES
JUNE 1990

EXECUTIVE SUMMARY

Four wood stoves certified by the U.S. Environmental Protection Agency to 1990 Phase II requirements were tested to determine the effects of various fuel loading densities and configurations on emissions performance. The EPA test protocol calls for testing with Douglas Fir lumber (2x4's and 4x4's) at a density of 7 lb/ft^3 of firebox volume and 1-1/2" (38 mm) spacing between pieces. The similar Canadian standard CSA B-415 requires a similar fuel but with a higher density and with one half the air space between pieces. Since the object of the laboratory emission test must be to predict field performance, it is important to understand how variables in fuel loading will affect wood stove performance.

The tests conducted and reported on here were designed to compare the performance of 4 different stove designs with 4 different fuel loading procedures as follows:

1. B-415 loading with 12 lb/ft^3 (192.2 kg/m^3)
2. B-415 loading with 10 lb./ft^3 (160.2 kg/m^3)
3. Oak Cordwood loading simulating consumer practice
4. EPA Method 28 loading of 7 lb/ft^3 (112.1 kg/m^3)

In addition, the data from the original EPA Certification tests of each stove were obtained.

The units tested included two catalytic and two non-catalytic models. The non-catalytic units included one with a relatively large firebox and one with a relatively small firebox. The catalytic units had similar firebox sizes, but varied in air control systems with one being thermostatically controlled by a bimetal spring and the other having a fixed manual control.

No consistent relationship is apparent in the results between fuel loading variations and performance. In some stoves, fueling parameters seem to have a more significant effect than in others, but in general average emissions rates do not appear to be greatly dependant on the loading variations investigated.

The test results do not point to a clear simple answer to the fuel variable question. Each stove produced both very low and relatively high emissions rates in some tests.

All stoves showed average emissions rates higher than their EPA Certified level. This is probably due to a variety of factors including the fact that the test units were production models, not test prototypes. Also, no special start-up procedures were used as may have been the case in the original EPA Certification tests. The variability of interlaboratory emission testing and variability between test methods within the EPA system are also likely causes of performance variation.

INTRODUCTION

The Technology Branch, Energy Mines and Resources, Canada, contracted with Warnock Hersey International to perform a series of wood stove emissions tests designed to determine the effects of fuel charge variations on emissions performance. A minimum of 12 test runs were conducted on each of four wood stoves. These tests consisted of three runs at various burn rates (EPA Categories 2, 3, and 4) using 4 different fuel loadings as follows:

1. Douglas Fir - B-415 specifications with fuel selected and arranged to produce a 12 lb/ft^3 loading density.

2. Douglas Fir - B-415 specifications with fuel selected to produce a 10 lb/ft^3 loading density.

3. Oak Cordwood loaded per WHA 1982 Standard for Testing the Heating Performance of Wood-Fired, Closed Combustion-Chamber Heating Appliances.

4. Douglas Fir - EPA method 28 specifications with fuel loading density of 7 lb/ft^3.

The stoves used were selected to represent a broad range of design types currently on the market. The selection criteria were established at the outset and the stoves were purchased directly from the manufacturers' stock.

In addition to the basic test results, the individual test results upon which EPA based their certification of the units were obtained.

BACKGROUND

The CSA B-415 committee is currently considering a proposal to revise the B-415 standard to bring it into agreement with the U.S. EPA emissions test protocol. One major change in this proposal is the use of the EPA fueling method which requires a 7 lb/ft^3 loading of dimension lumber (2x4's and/or 4x4's) with 1-1/2" spaces between pieces. The current B-415 loading protocol uses similar fuel pieces, dimension Douglas Fir lumber, but controls the loading on a purely dimensional system. Typical loading in accordance with B-415 requirement produces loading densities ranging from about 8.5 to 12 pounds per cubic foot of firebox volume.

There is considerable controversy regarding the question of whether or not "artificial" loading procedures, designed to be reproduced in the laboratory, accurately reflect expected field performance. It has been widely assumed that consumer cordwood loading patterns are highly variable with respect to all important fuel parameters. Thus, if laboratory testing is to be a useful indicator of field emissions performance, one needs some confidence that a particular appliance design which produces acceptably low emissions rates in the laboratory will also perform well in the "real world".

Several field tests have been conducted over the course of the last few winters wherein emissions rates from "Certified" clean burning stoves were monitored in consumers' homes. The results of these studies have been largely inconclusive but do show many instances where very high emissions rates, some an order of magnitude above certification levels, were obtained routinely. While many factors other than fuel characteristics are likely to cause significant performance differences, fuel is certainly a major area which requires investigation to provide support for reasonable decision making in designing laboratory protocols that will better predict field performance.

BACKGROUND continued

The study undertaken in this project was designed to isolate the variable of fuel loading density, in terms of weight of wood per unit of firebox volume. The results of varied densities using standard Douglas Fir lumber were also compared to run using cordwood loading designed to be "typical" of assumed consumer practice. The questions which this project was designed to answer were:

1. Does loading density have a significant and identifiable effect on emissions performance?

2. If loading density does cause significant performance variations, are the variations:

   a. predictable?

   b. consistent regardless of stove technology?

   c. consistent within a stove technology?

3. Does any particular laboratory fuel or fueling procedure correlate better than others with field performance?

UNITS TESTED

The units selected for this project were chosen on the basis of the following criteria:

1. Only one unit from any single manufacturer.
2. EPA Phase II (1990) Certified.
3. Simple air control system with single adjustment.
4. 2 catalytic and 2 non-catalytic units.
5. Different certification laboratories for each unit.
6. Price under $1000 U.S.

The units selected were as follows:

1. Regency Industries Model: R6
   Type: Non-catalytic
   Firebox Volume: 2.18 ft^3
   EPA Emissions Rate: 3.9 g/hr

2. Sweet Home (Sierra) Model: AFX-HT
   Type: Non-catalytic
   Firebox Volume: 1.68 ft^3
   EPA Emissions Rate: 6.4 g/hr

3. New Buck Corporation Model: Carolina 41 CD
   Type: Catalytic
   Firebox Volume: 1.89 ft^3
   EPA Emissions Rate: 2.6 g/hr

4. Suburban Manufacturing Model: Woodmaster
   Type: Catalytic
   Firebox Volume: 2.17 ft^3
   EPA Emissions Rate: 3.4 g/hr

PROCEDURE

Units were purchased from the manufacturer and shipped directly to the laboratory. Each unit was carefully inspected upon receipt for damage or defects. All units were found to be in satisfactory condition.

Units were operated for 10 hours for the non-catalytic units and 50 hours for the catalytic units with hardwood cordwood prior to testing. Each unit was tested for emissions and efficiency at 3 different burn rates with each of the 4 prescribed fuel loads. Tests were conducted using the current EPA procedures including all standard Quality Assurance procedures. Emissions rates were measured using a dilution tunnel and dual 47 millimeter sample trains. Efficiencies were calculated as prescribed in the current version of CSA B-415.

A total of 53 test runs were made during this project.

RESULTS

Test results are presented in Table A and Tables I-IV. Graphs 1-12 are plots of the pertinent data. Appendices A - D contain detailed summaries and individual test run data.

DISCUSSION

All tests reported on herein were successful runs with no deviation from Quality Assurance requirements. One test, the high burn rate test of the Suburban Woodmaster stove with a 12 lb/ft^3 loading, appears to be an outlier with a very high emissions rate. The other data taken during this test indicated that this was a real emissions result. We could not find any evidence of a fault in the test conducted such as a bypass left open or a leak around the door. Unfortunately, time and budget did not allow for a replication of this test. It is our conclusion, however, that this result should be discarded as a statistical outlier since it shows little similarity to the other tests of this unit.

DISCUSSION continued

The results generally indicate that the fuel charge variable had little effect on emissions. Table A shows weighted average emissions rates and efficiencies per EPA weighting methods.

TABLE A
WEIGHTED AVERAGES[1]

	STOVE											
	R6			AFX-HT			WOOD MASTER			CAROLINA		
LOAD	PM (g/hr)	CO (g/hr)	EFF (%)	PM (g/hr)	CO (g/hr)	EFF (%)	PM (g/hr)	CO (g/hr)	EFF (%)	PM (g/hr)	CO (g/hr)	EFF (%)
EPA Cert.	3.9	----	----	6.4	----	----	3.4	----	----	2.6	----	----
7 lb/ft^3	14.7	194.1	69.2	7.0	99.4	71.3	13.5	90.3	73.6	8.7	116.4	74.1
10 lb/ft^3	16.3	222.8	67.8	7.9	136.0	71.4	5.6	43.3	74.9	4.6	110.4	73.1
12 lb/ft^3	13.7	232.2	68.8	7.5	131.1	72.9	6.5[2]	125.9[2]	80.1	5.6	112.9	72.1
Oak Cord.	14.2	196.1	58.8	7.6	208.3	72.5	3.8	72.1	76.0	7.6	112.5	68.6

[1]Weightings are as specified in US EPA Method 28.

[2]Does not include suspected outlier. Value with outlier is 11.3 g/hr and 157.5 g/hr CO.

OBSERVATIONS

Regency R6

This unit produced particulate emissions rates well above its certification levels with all four fuels. There was, however, no significant difference in its average emissions rates related to the fuel variations.

It produced its lowest emissions rates at high burn rates as expected, but the only low emissions run at a low burn rate was achieved with cordwood (2.1 g/hr at 1.66 kg/hr burn rate). In all runs with burn rates in EPA's Category 2 (under 1.25 kg/hr burn rate), the emissions rates were very high, averaging over 20 g/hr.

REGENCY R6 10 LB/FT³

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
5	257.8	20.88	.2824	.8924	18.6297	65.26	58.24	230.0
3	181.3	11.33	.8924	.6636	7.5199	71.37	47.36	120.3
2	213.7	14.33	.9360	.1034	1.4821	73.48	7.60	22.1
7	179.6	7.87	.9958	.0640	.5039	56.99	3.65	11.5
Sums:				1.7234	28.1357		116.84	383.9

Weighted Average PM Emissions Rate: 28.1357 ÷ 1.7234 = 16.3257 g/hr
Weighted Average CO Emissions Rate: 383.9 ÷ 1.7234 = 222.8 g/hr
Weighted Average Overall Heating Efficiency: 116.84 ÷ 1.7234 = 67.80%

* Calculated as specified in CSA B-415

REGENCY R6 12 LB/FT³
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
8	201.8	10.20	.4660	.7558	7.7117	70.14	53.01	152.5
6	304.8	23.40	.7558	.4238	9.9153	69.05	29.26	129.2
4	227.5	12.03	.8898	.2332	2.8054	70.85	16.52	53.1
1	171.3	4.41	.9892	.1102	.4863	54.60	6.02	18.9
Sums:				1.523	20.9187		104.81	353.6

Weighted Average PM Emissions Rate: 20.9187 ÷ 1.523 = 13.7352 g/hr
Weighted Average CO Emissions Rate: 353.6 ÷ 1.523 = 232.2 g/hr
Weighted Average Overall Heating Efficiency: 104.81 ÷ 1.523 = 68.82%

* Calculated as specified in CSA B-415

REGENCY R6 RED OAK CORDWOOD

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
12	178.2	27.93	.1871	.8280	23.1260	54.52	45.06	147.5
13	146.0	2.11	.8280	.7707	1.6231	65.40	50.40	112.5
11	200.7	2.53	.9578	.1720	.4346	50.23	8.64	87.2
Sums:				1.7707	25.1838		104.10	347.3

Weighted Average PM Emissions Rate: 25.1838 ÷ 1.7707 = 14.2225 g/hr
Weighted Average CO Emissions Rate: 347.3 ÷ 1.7707 = 196.1 g/hr
Weighted Average Overall Heating Efficiency: 104.10 ÷ 1.7707 = 58.79%

* Calculated as specified in CSA B-415

REGENCY R6 EPA 7 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
10	225.8	22.187	.4660	.7558	16.7689	70.58	53.34	170.6
2E	211.5	9.480	.7558	.5290	5.0149	69.89	37.02	111.9
1E	58.6	3.115	.9950	.2442	.7607	63.44	15.49	14.3
Sums:				1.529	22.5445		105.86	296.8

Weighted Average PM Emissions Rate: 22.5445 ÷ 1.529 = 14.7446 g/hr
Weighted Average CO Emissions Rate: 296.8 ÷ 1.529 = 194.1 g/hr
Weighted Average Overall Heating Efficiency: 105.86 ÷ 1.529 = 69.23%

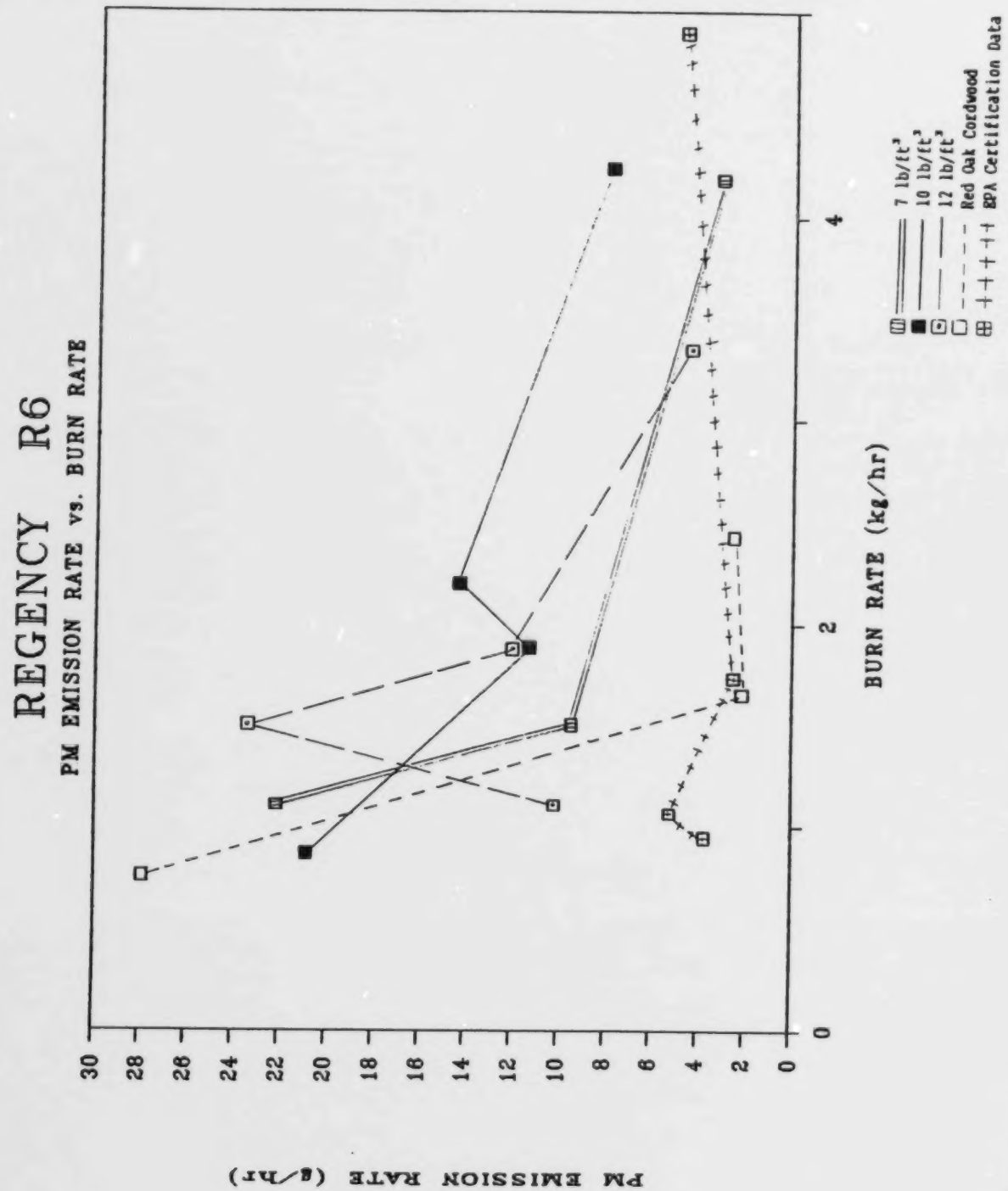
* Calculated as specified in CSA B-415

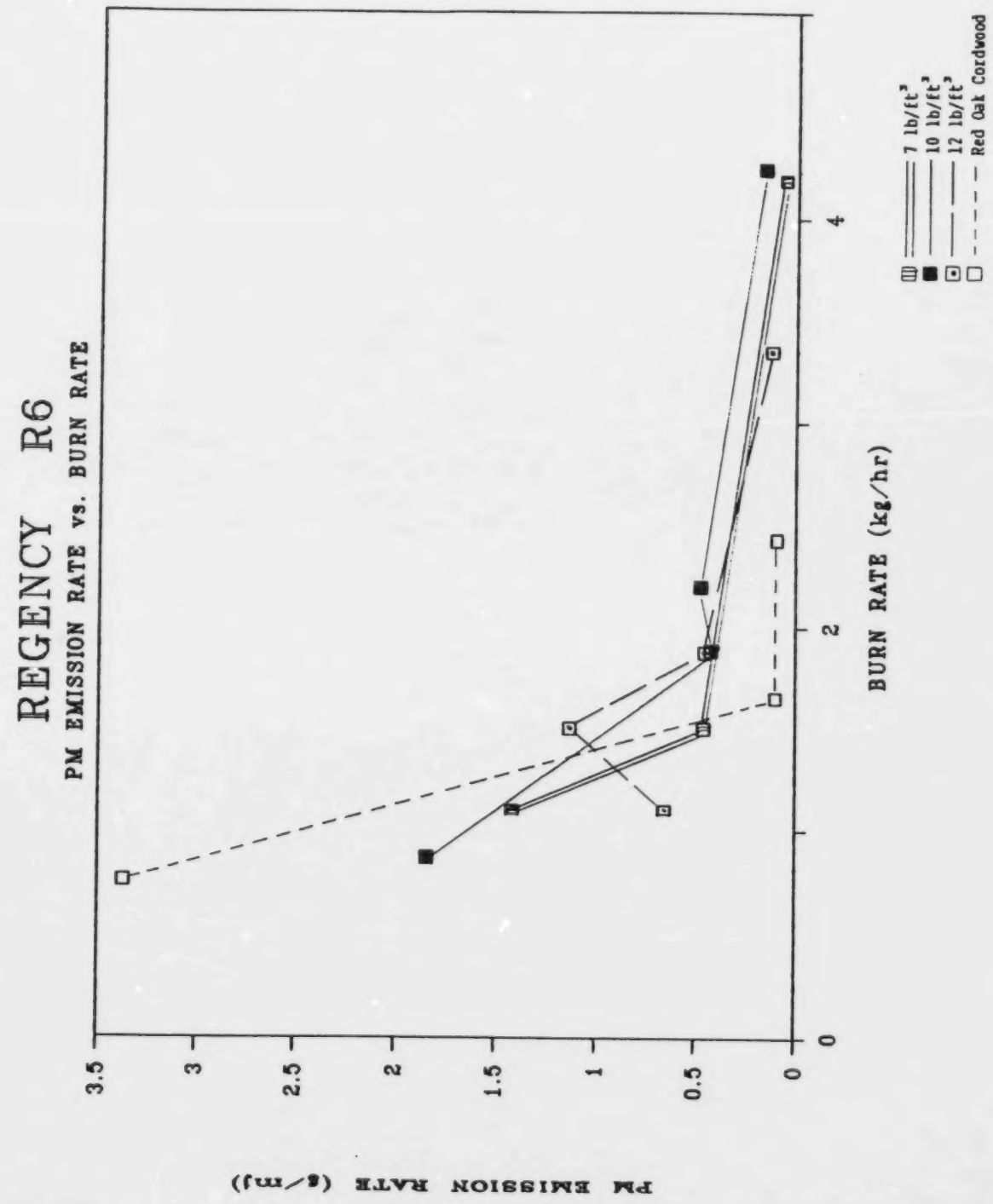
WARNCCK HERSEY INTERNATIONAL, INC. TEST REPORT #632-911300
FUEL LOADING DENSITY EFFECTS ON WOOD STOVE EMISSIONS RATES
PREPARED FOR: TECHNOLOGY BRANCH, ENERGY MINES AND RESOURCES
JUNE 1990

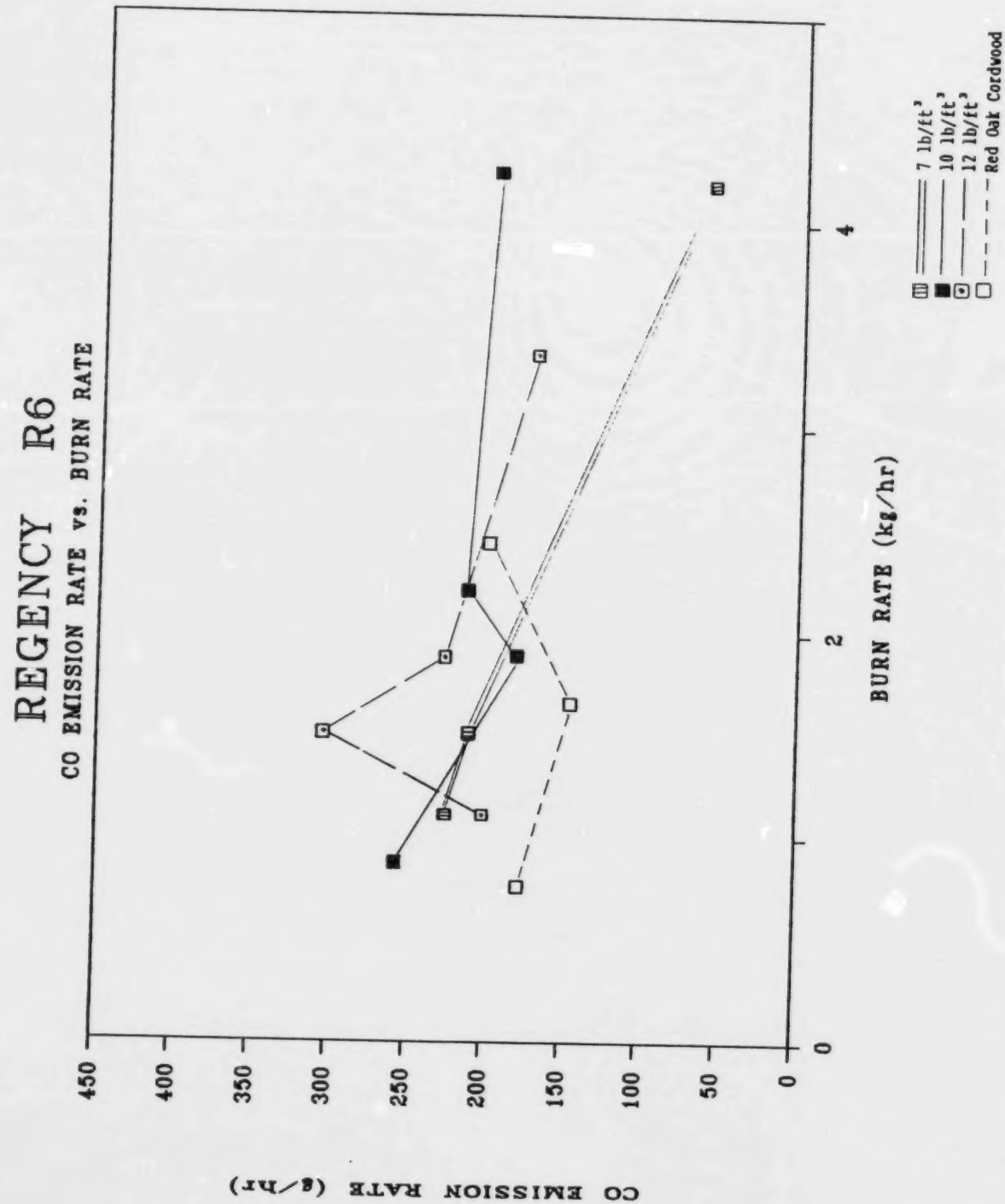
TABLE 1

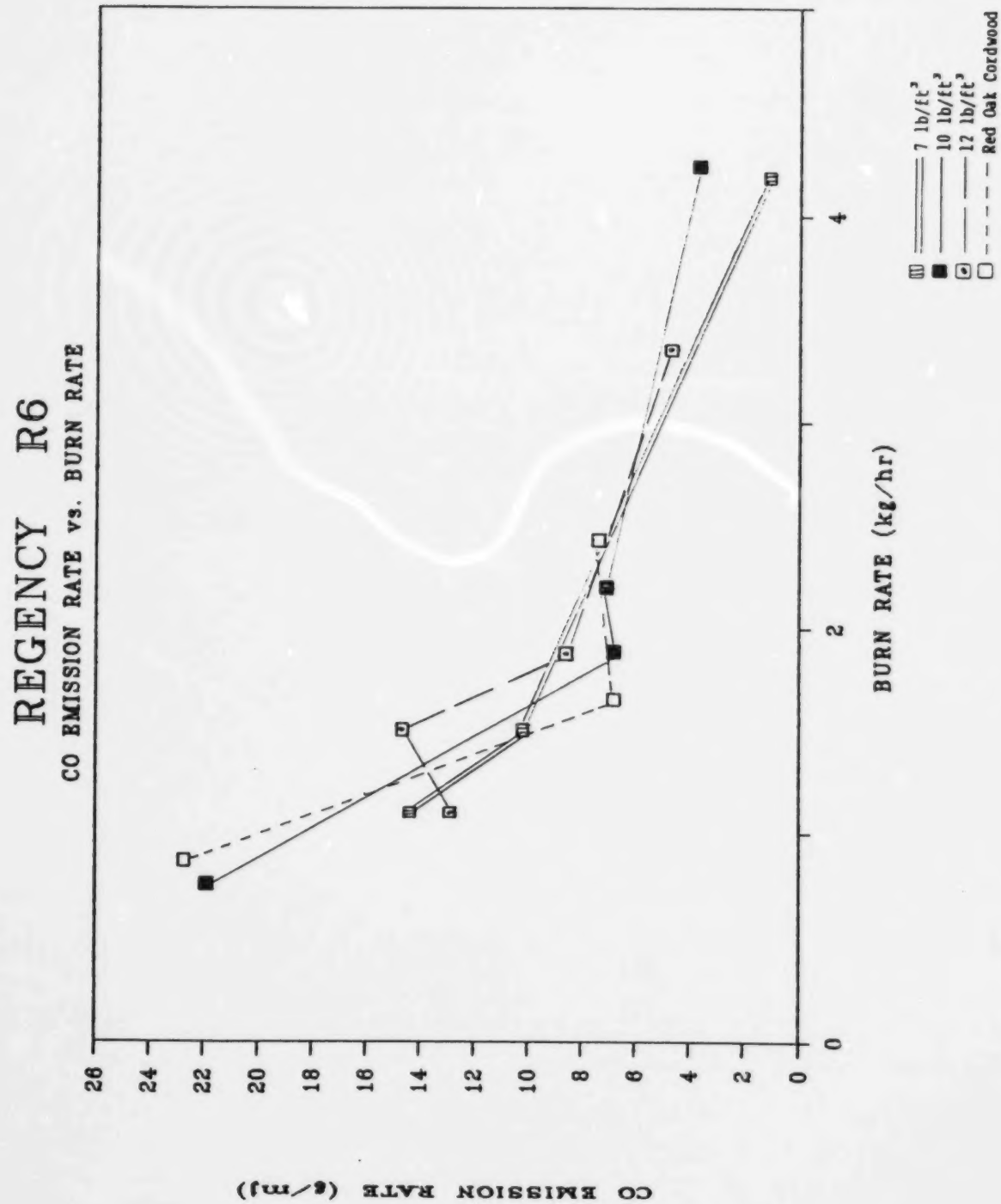
REGENCY MODEL: R6

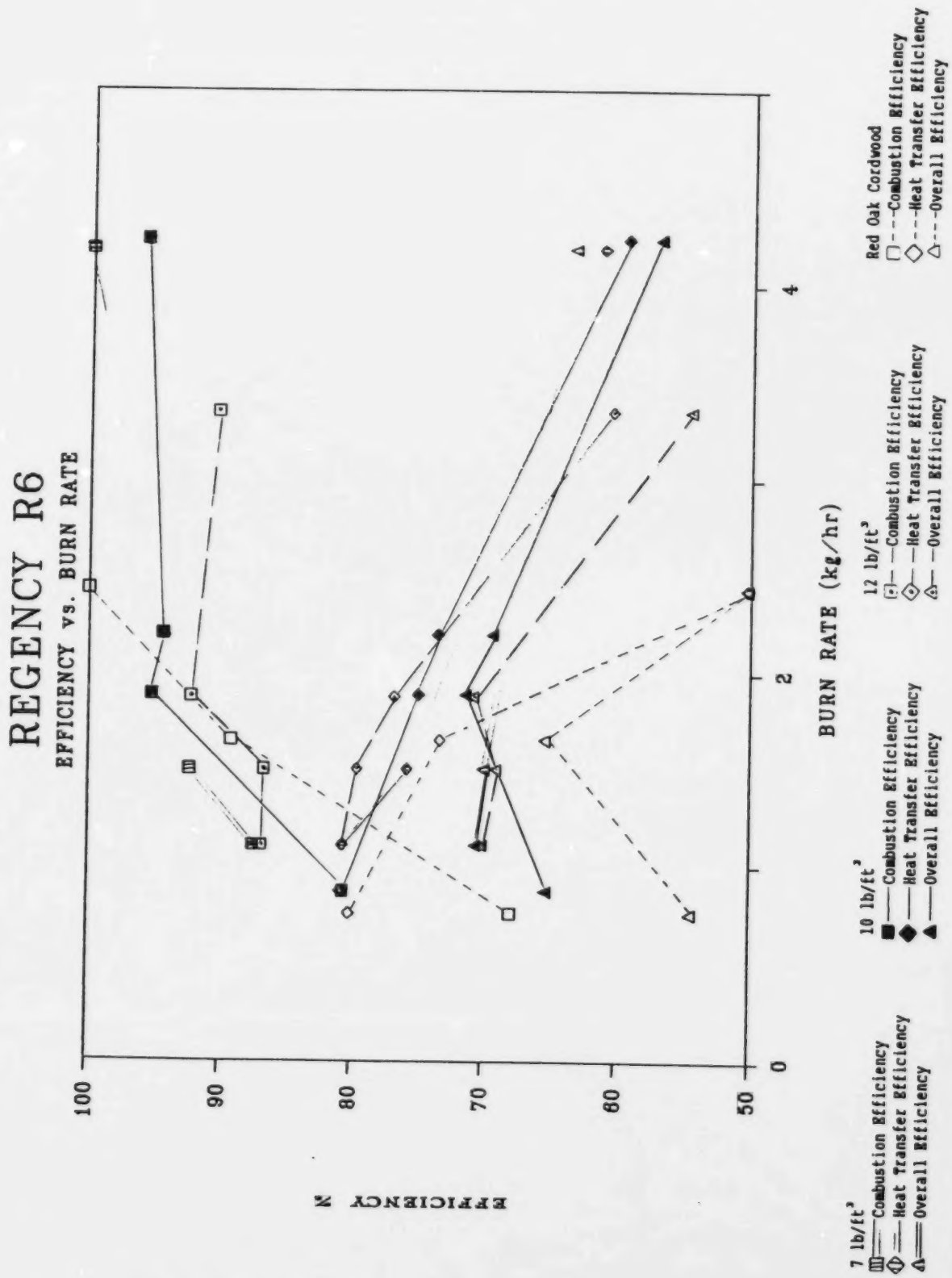
LOAD TYPE	RUN NUMBER	BURN RATE	EMISSION RATE CO g/hr	EMISSION RATE PM g/hr	EMISSION RATE CO g/mj	EMISSION RATE PM g/mj	EFFICIENCIES Combustion	EFFICIENCIES Heat Transfer	EFFICIENCIES Overall	DENSITY lb/ft	MOISTURE CONTENT
10 LB/FT	2	2.20	213.7	14.334	7.1	0.476	94.40	73.48	69.37	9.94	21.32
	3	1.89	181.3	11.332	6.8	0.425	95.25	74.93	71.37	10.41	21.52
	5	0.87	257.8	20.876	22.7	1.840	80.66	80.90	65.26	9.92	23.05
	7	4.24	197.6	7.874	3.7	0.164	95.91	59.42	56.99	9.97	22.32
12 LB/FT	1	3.35	171.3	4.413	4.7	0.121	90.34	60.43	54.60	12.00	22.96
	4	1.88	227.5	12.030	8.6	0.457	92.27	76.77	70.85	11.98	21.76
	6	1.51	304.8	23.396	14.7	1.130	86.71	79.62	69.05	12.04	23.61
	8	1.11	201.8	10.203	12.9	0.654	86.91	80.70	70.14	12.11	22.92
RED OAK CORDWOOD	11	2.43	200.7	2.527	7.4	0.093	99.99	50.16	50.23	9.34	20.70
	12	0.75	178.2	27.930	21.9	3.369	67.92	80.13	54.42	8.97	22.63
	13	1.66	146.0	2.106	6.8	0.098	89.24	73.28	65.40	8.68	22.35
7 LB/FT (EPA)	10	1.11	225.8	22.187	14.4	1.413	87.52	80.65	70.58	6.55	22.90
	1R	4.19	58.6	3.115	1.1	0.059	99.99	61.22	63.44	6.56	20.73
	2R	1.51	211.5	9.480	10.2	0.459	92.33	75.79	69.98	6.74	20.33
EPA	1	0.95		3.700						6.90	22.00
CERTIFICATION	5	1.07		5.200						7.20	22.00
DATA	6	1.74		2.500						7.20	22.00
	2	4.90		4.700						6.80	22.00


REGENCY R6
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
2
4
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
EPA Certification Data


REGENCY R6
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/mj)
BURN RATE (kg/hr)
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


REGENCY R6
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
50
100
150
200
250
300
350
400
450
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


REGENCY R6
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/mj)
BURN RATE (kg/hr)
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
0
2
4
6
8
10
12
14
16
18
20
22
24
26


REGENCY R6
EFFICIENCY vs. BURN RATE
EFFICIENCY %
BURN RATE (kg/hr)
100
90
80
70
60
50
0
2
4
7 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
10 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
12 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
Red Oak Cordwood
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency

OBSERVATIONS continued

Sweet Home AFX-HT

This unit showed performance closest to its certification level and remarkably consistent across the fuel types used. This unit would seem to demonstrate that some unit designs are relatively insensitive to the range of fuel loading parameters evaluated in this project.

SWEET HOME AFX-HT 10 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
6	165.2	10.82	.4720	.6008	6.5013	69.19	41.57	99.3
1	153.7	8.13	.6008	.5066	4.1182	72.35	36.65	77.9
4	69.6	3.16	.9786	.3992	1.2623	73.53	29.35	27.8
Sums:				1.5066	11.8817		107.58	204.9

Weighted Average PM Emissions Rate: 11.8817 ÷ 1.5066 = 7.8864 g/hr
Weighted Average CO Emissions Rate: 204.9 ÷ 1.5066 = 136.0 g/hr
Weighted Average Overall Heating Efficiency: 107.58 ÷ 1.5066 = 71.40%

* Calculated as specified in CSA B-415

SWEET HOME AFX-HT 12 LB/FT^3

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
3	144.8	7.04	.5020	.7388	5.2026	73.72	54.46	107.0
5	137.2	8.25	.7388	.4812	3.9713	72.43	34.85	66.0
2	81.1	7.32	.9832	.2612	1.9122	81.62	18.71	21.2
Sums:				1.4812	11.0862		108.02	194.2

Weighted Average PM Emissions Rate: 11.0862 ÷ 1.4812 = 7.4846 g/hr
Weighted Average CO Emissions Rate: 194.2 ÷ 1.4812 = 131.1 g/hr
Weighted Average Overall Heating Efficiency: 108.02 ÷ 1.4812 = 72.93%

* Calculated as specified in CSA B-415

SWEET HOME AFX-HT RED OAK CORDWOOD

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
9	201.6	12.25	.4070	.7112	8.7122	71.64	50.95	143.4
10	155.2	3.15	.7112	.5440	1.7109	76.26	41.49	84.4
8	324.8	4.40	.9510	.2888	1.2704	67.31	19.44	93.8
Sums:				1.544	11.6935		111.87	321.6

Weighted Average PM Emissions Rate: 11.6935 ÷ 1.544 = 7.5735 g/hr
Weighted Average CO Emissions Rate: 321.6 ÷ 1.544 = 208.3 g/hr
Weighted Average Overall Heating Efficiency: 111.87 ÷ 1.544 = 72.46%

* Calculated as specified in CSA B-415

SWEET HOME APX-HT EPA 7 LB/FT ^{3}
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
7	109.9	7.274	.6336	.7388	5.3740	72.10	53.27	81.2
2E	110.1	9.545	.7388	.3328	3.1766	70.13	23.34	36.6
1E	56.2	2.805	.9664	.2612	.7327	70.65	18.45	14.7
Sums:				1.3328	9.2833		95.06	132.5

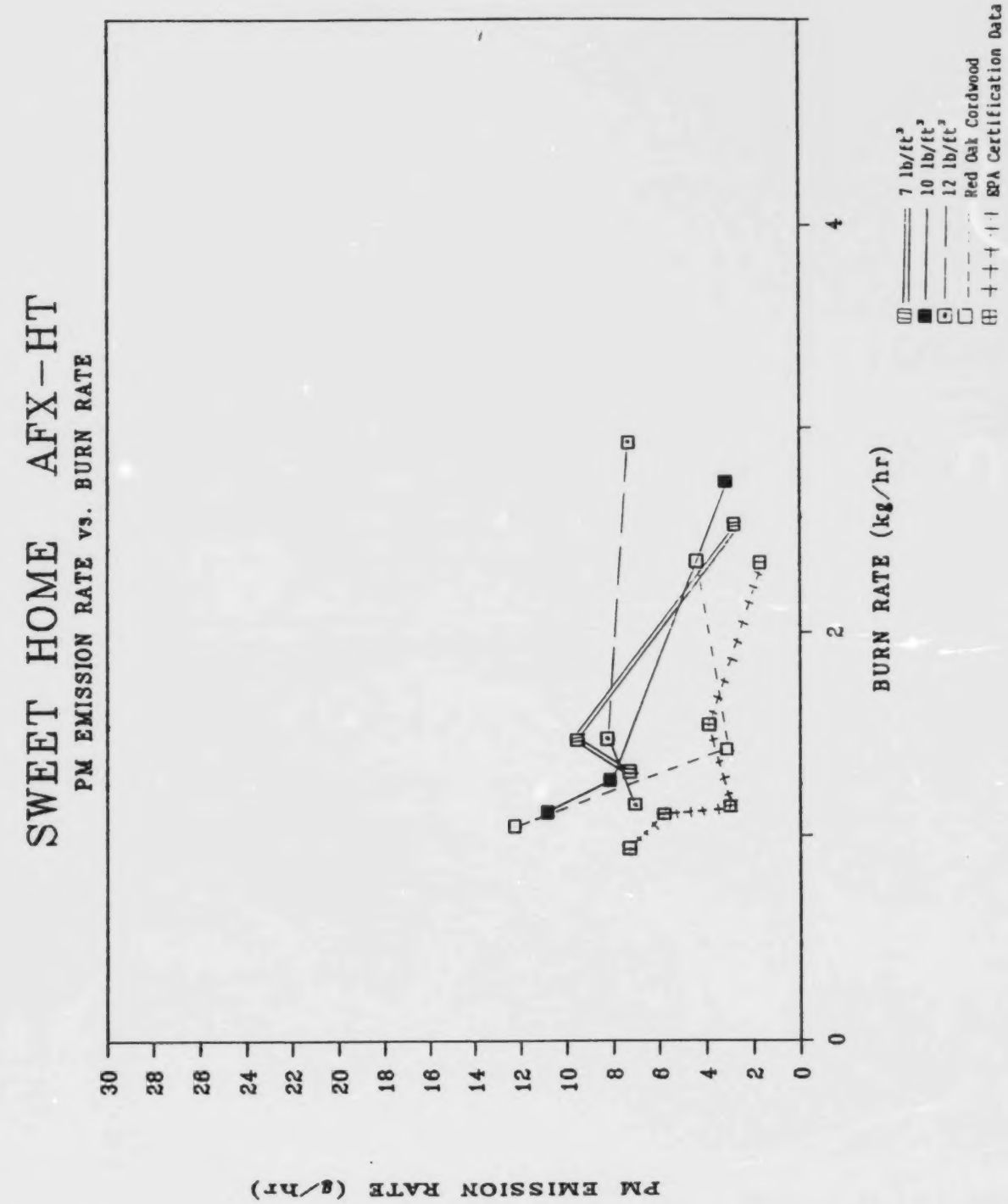
Weighted Average PM Emissions Rate: 9.2833 ÷ 1.3328 = 6.9652 g/hr
Weighted Average CO Emissions Rate: 132.5 ÷ 1.3328 = 99.4 g/hr
Weighted Average Overall Heating Efficiency: 95.06 ÷ 1.3328 = 71.32%

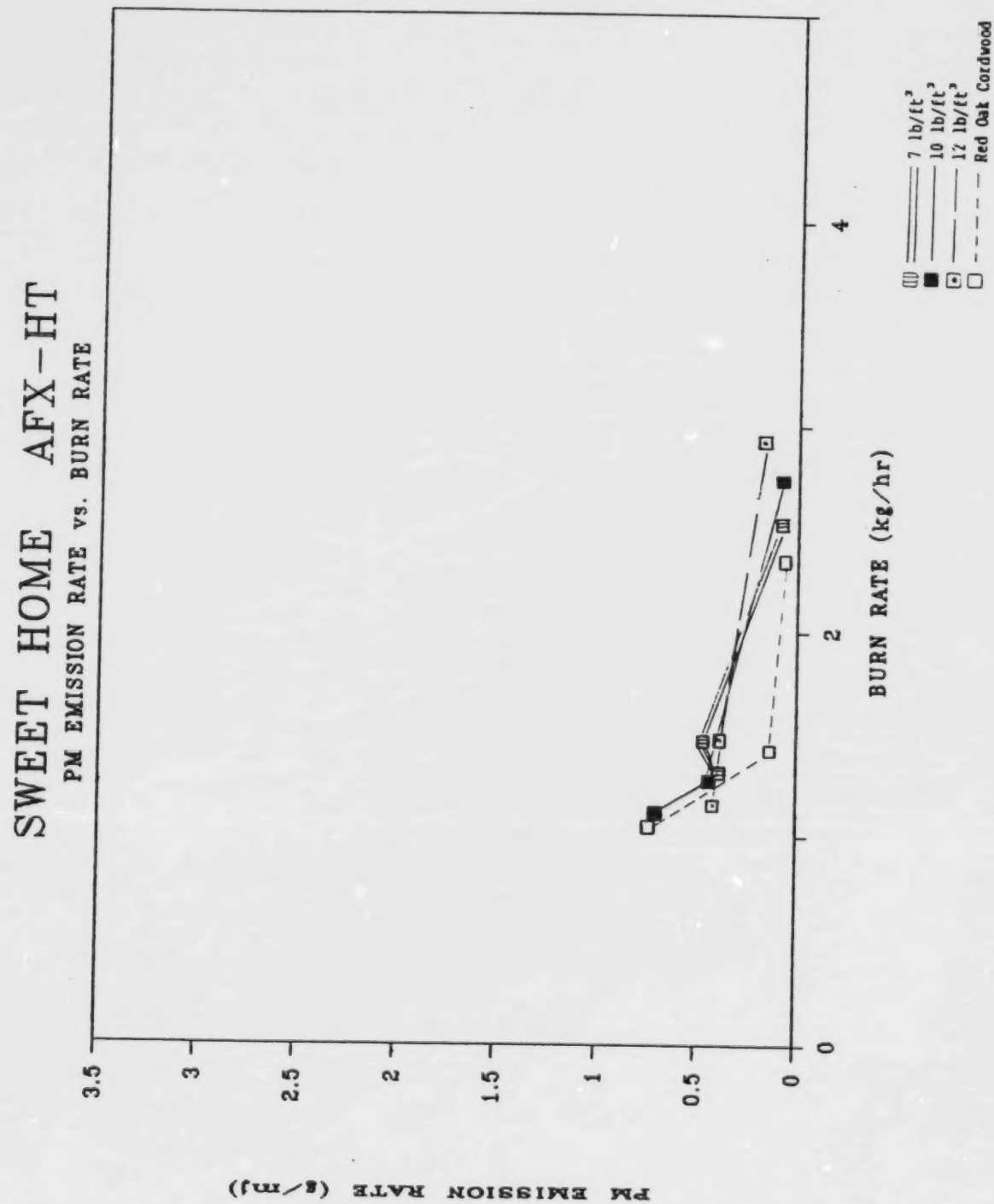
* Calculated as specified in CSA B-415

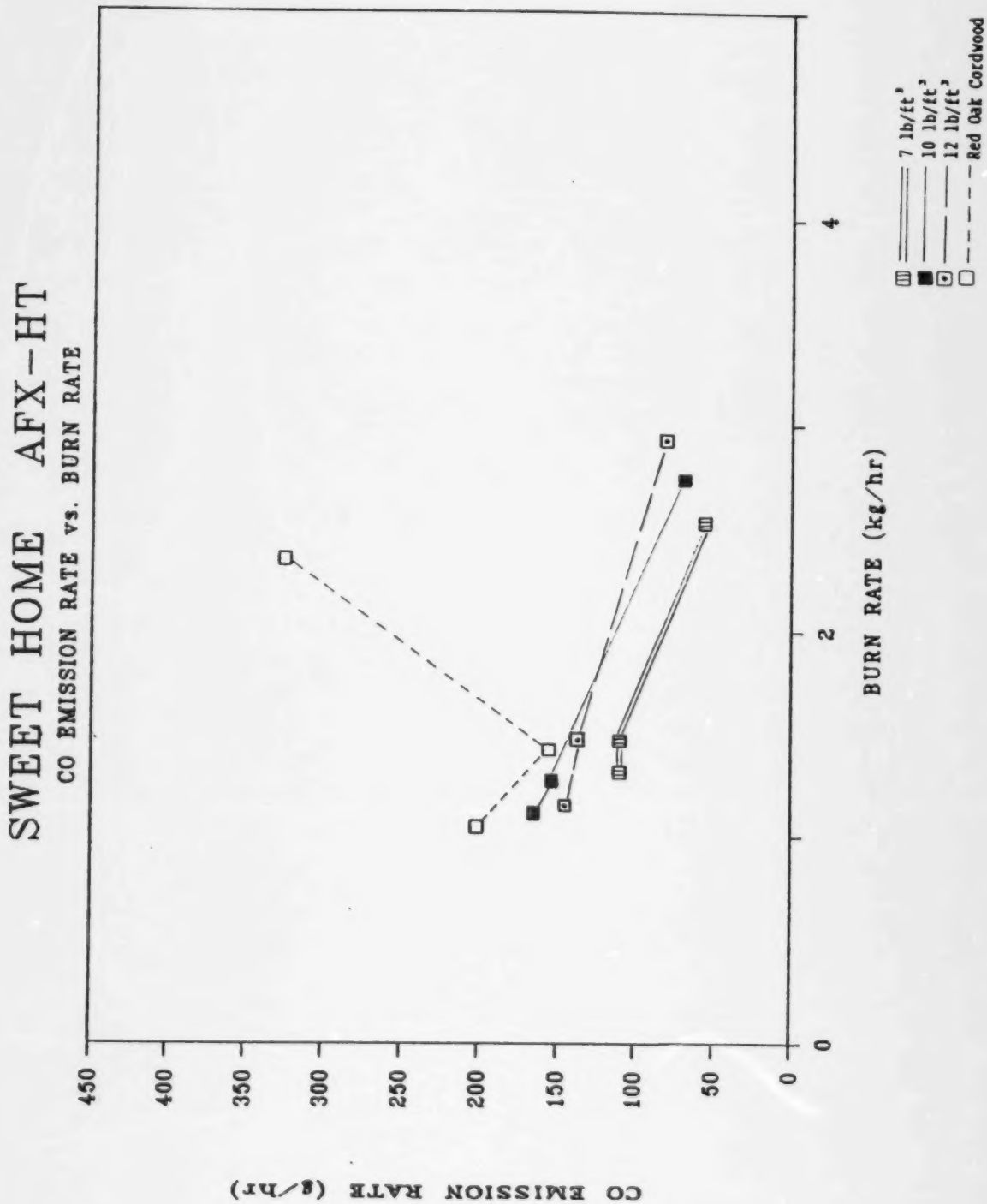
TABLE 2

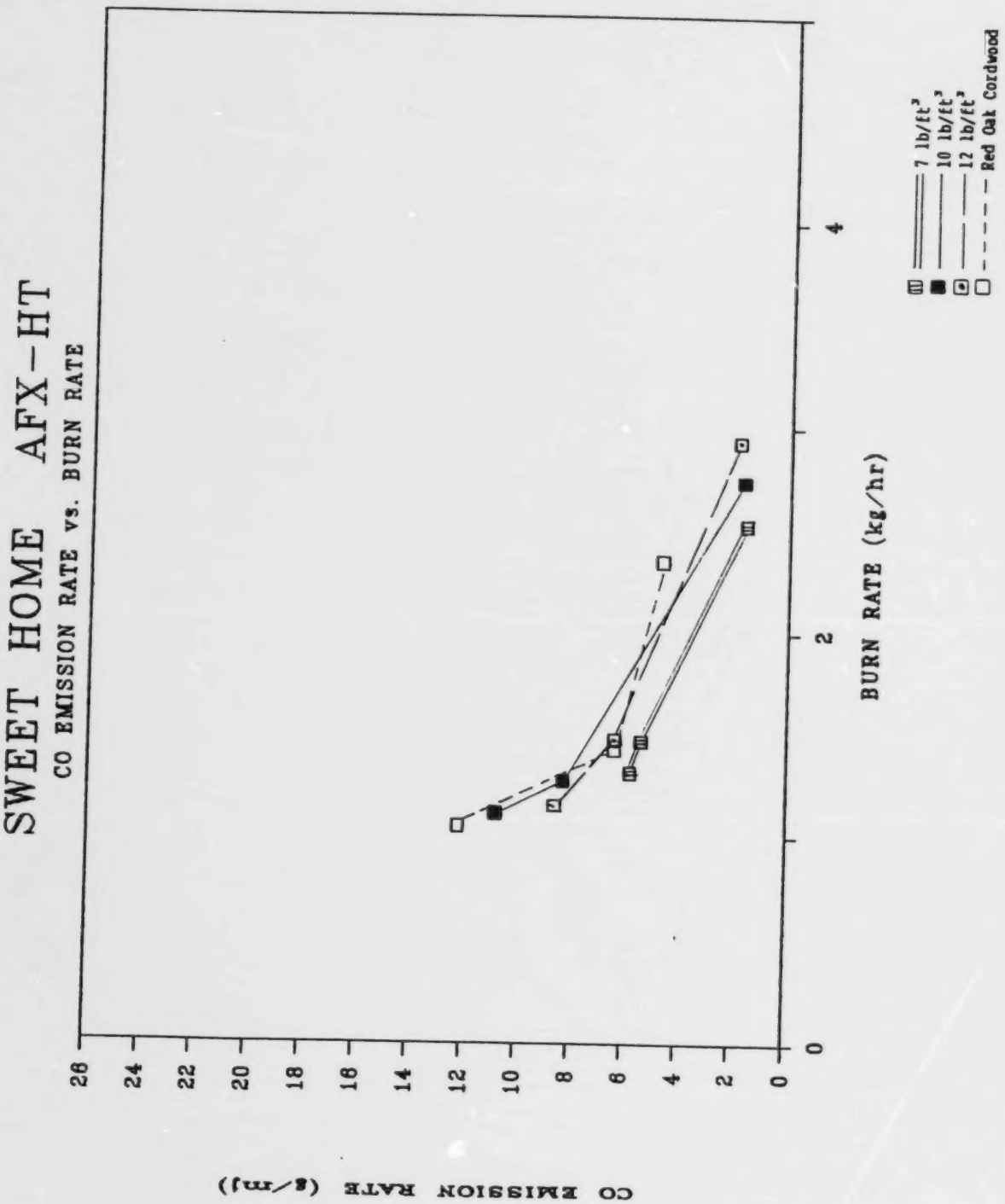
SVEET HOME MODEL: APX-HT

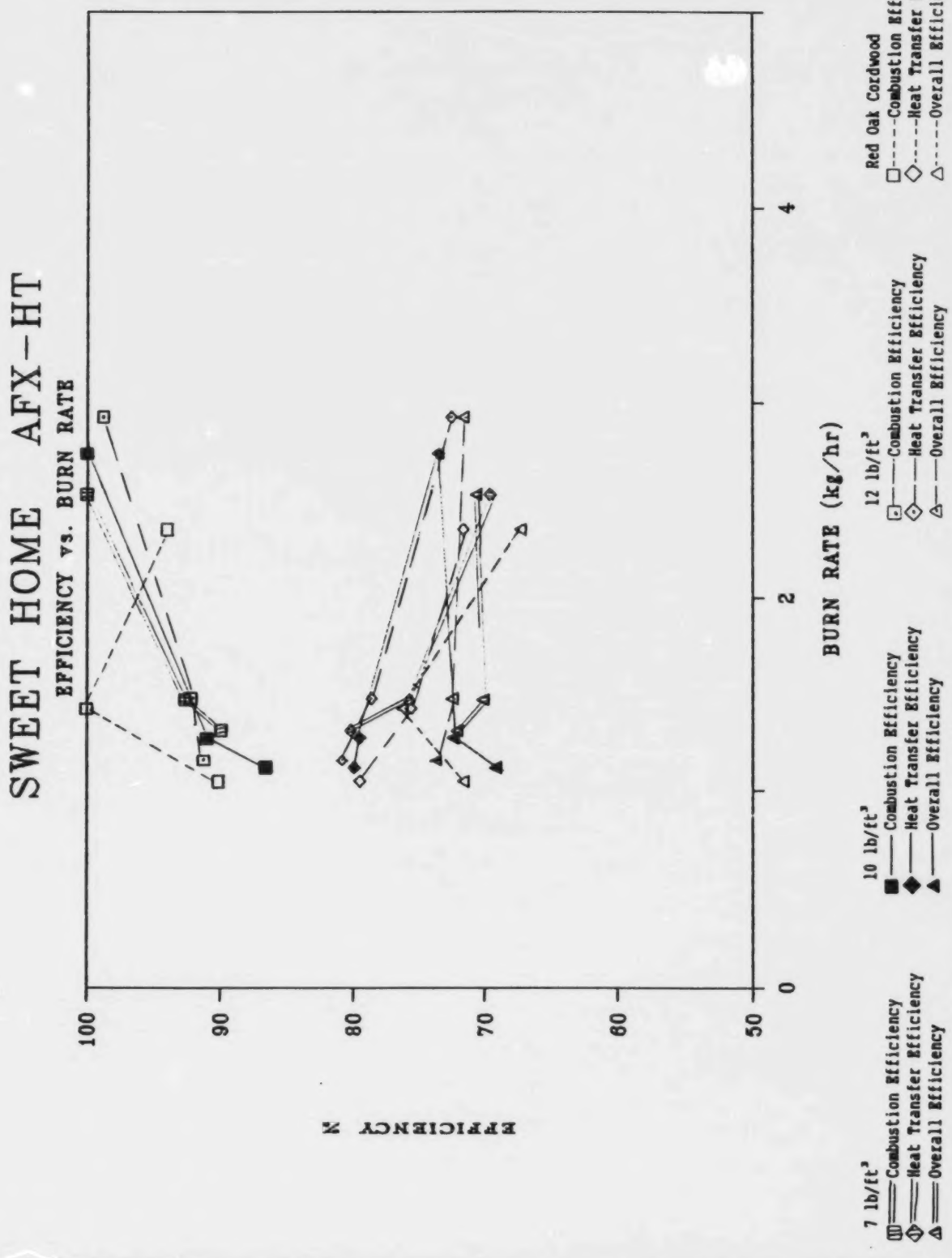
LOAD TYPE	RUN NUMBER	BURN RATE	EMISSION RATE CO g/hr	EMISSION RATE PM g/hr	EMISSION RATE CO g/mj	EMISSION RATE PM g/mj	EFFICIENCIES Combustion	EFFICIENCIES Heat Transfer	EFFICIENCIES Overall	DENSITY lb/ft	MOISTURE CONTENT
10 LB/FT	1	1.28	153.7	8.129	8.3	0.441	91.00	79.50	72.35	10.26	21.26
	4	2.74	69.6	3.162	1.7	0.079	99.99	73.48	73.53	10.25	22.19
	6	1.12	165.2	10.821	10.8	0.704	86.59	79.90	69.19	10.46	22.08
12 LB/FT	2	2.93	81.1	7.321	1.9	0.174	98.78	72.50	71.62	12.07	23.09
	3	1.16	144.8	7.042	8.6	0.417	91.23	80.81	73.72	11.95	21.62
	5	1.48	137.2	8.253	6.4	0.384	92.19	78.56	72.43	12.18	23.55
RED OAK	8	2.35	324.8	4.399	4.7	0.064	93.98	71.62	67.31	8.56	20.60
CORDWOOD	9	1.05	201.6	12.250	12.2	0.740	90.16	79.46	71.64	8.35	21.34
	10	1.43	155.2	3.145	6.4	0.131	99.99	75.56	76.26	8.40	21.07
7 LB/FT (EPA)	7	1.32	105.9	7.274	5.8	0.385	89.91	80.18	72.10	6.69	20.71
	1E	2.53	56.2	2.805	1.6	0.080	99.99	69.59	70.65	6.89	20.99
	2E	1.48	110.1	9.545	5.4	0.468	92.64	75.70	70.13	6.89	20.41
EPA	6	0.94		7.300						7.40	24.00
CERTIFICATION	2	1.11		5.800						7.00	24.00
DATA	4	1.15		3.000						7.10	25.00
	5	1.55		3.900						7.30	25.00
	3	2.34		1.700						6.90	22.00


SWEET HOME AFX-HT
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
2
4
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
EPA Certification Data


SWEET HOME AFX-HT
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/mJ)
BURN RATE (kg/hr)
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
0
0.5
1
1.5
2
2.5
3
3.5
0
2
4


SWEET HOME AFX-HT
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
50
100
150
200
250
300
350
400
450
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


SWEET HOME AFX-HT
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/mj)
BURN RATE (kg/hr)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


SWEET HOME AFX-HT
EFFICIENCY vs. BURN RATE
EFFICIENCY %
100
90
80
70
60
50
0
2
4
BURN RATE (kg/hr)
7 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
10 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
12 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
Red Oak Cordwood
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency

OBSERVATIONS continued

Suburban Woodmaster

This unit showed wider variability in performance than is normally expected of catalytic units. The cordwood loading produced the best results in terms of emissions rates and the only result which met EPA certification limits for this unit. However, the EPA fuel loading runs were all very high in emissions rates. This was the only unit which appears to show a significant fuel related performance variation.

SUBURBAN WOODMASTER 10 LB/FT³
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
2	12.7	3.81	.3280	.7916	3.0176	77.60	61.43	10.0
8	72.3	7.68	.7916	.6072	4.6621	73.46	44.60	43.9
1	75.3	6.21	.9352	.2084	1.2944	68.96	14.37	15.7
Sums:				1.6072	8.9740		120.40	69.6

Weighted Average PM Emissions Rate: 8.9740 ÷ 1.6072 = 5.5836 g/hr
Weighted Average CO Emissions Rate: 69.6 ÷ 1.6072 = 43.3 g/hr
Weighted Average Overall Heating Efficiency: 120.40 ÷ 1.6072 = 74.91%

* Calculated as specified in CSA B-415

SUBURBAN WOODMASTER 12 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
6	41.9	7.03	.4600	.8502	5.9769	79.03	67.19	35.6
7	260.1	6.00	.8502	.5320	3.1920	85.99	45.75	138.4
11	449.1	54.28	.9920	.1498	8.1311	65.49	9.81	67.3
Sums:				1.532	17.3001		122.75	241.3

Weighted Average PM Emissions Rate: 17.3001 ÷ 1.532 = 11.2925 g/hr
Weighted Average CO Emissions Rate: 241.3 ÷ 1.532 = 157.5 g/hr
Weighted Average Overall Heating Efficiency: 122.75 ÷ 1.532 = 80.12%

* Calculated as specified in CSA B-415

SUBURBAN WOODMASTER RED OAK CORDWOOD

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
10	39.8	4.28	.6008	.6540	2.7991	78.62	51.42	26.0
5	92.7	2.29	.6540	.2770	.6352	73.59	20.38	25.7
4	135.4	4.92	.8778	.2870	1.4120	73.68	21.15	38.9
3	50.1	2.18	.9410	.1222	.2664	73.19	8.94	6.1
Sums:				1.3402	5.1127		101.89	96.7

Weighted Average PM Emissions Rate: 5.1127 ÷ 1.3402 = 3.8149 g/hr
Weighted Average CO Emissions Rate: 96.7 ÷ 1.3402 = 72.1 g/hr
Weighted Average Overall Heating Efficiency: 101.89 ÷ 1.3402 = 76.03%

* Calculated as specified in CSA B-415

SUBURBAN WOODMASTER EPA 7 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
9	48.2	11.989	.5544	.9108	10.9196	76.55	69.72	43.9
2E	116.5	16.710	.9108	.4288	7.3323	69.22	30.37	49.9
3E	404.9	13.280	.9932	.0892	1.1846	65.01	5.80	36.1
Sums:				1.4388	19.4365		105.89	129.9

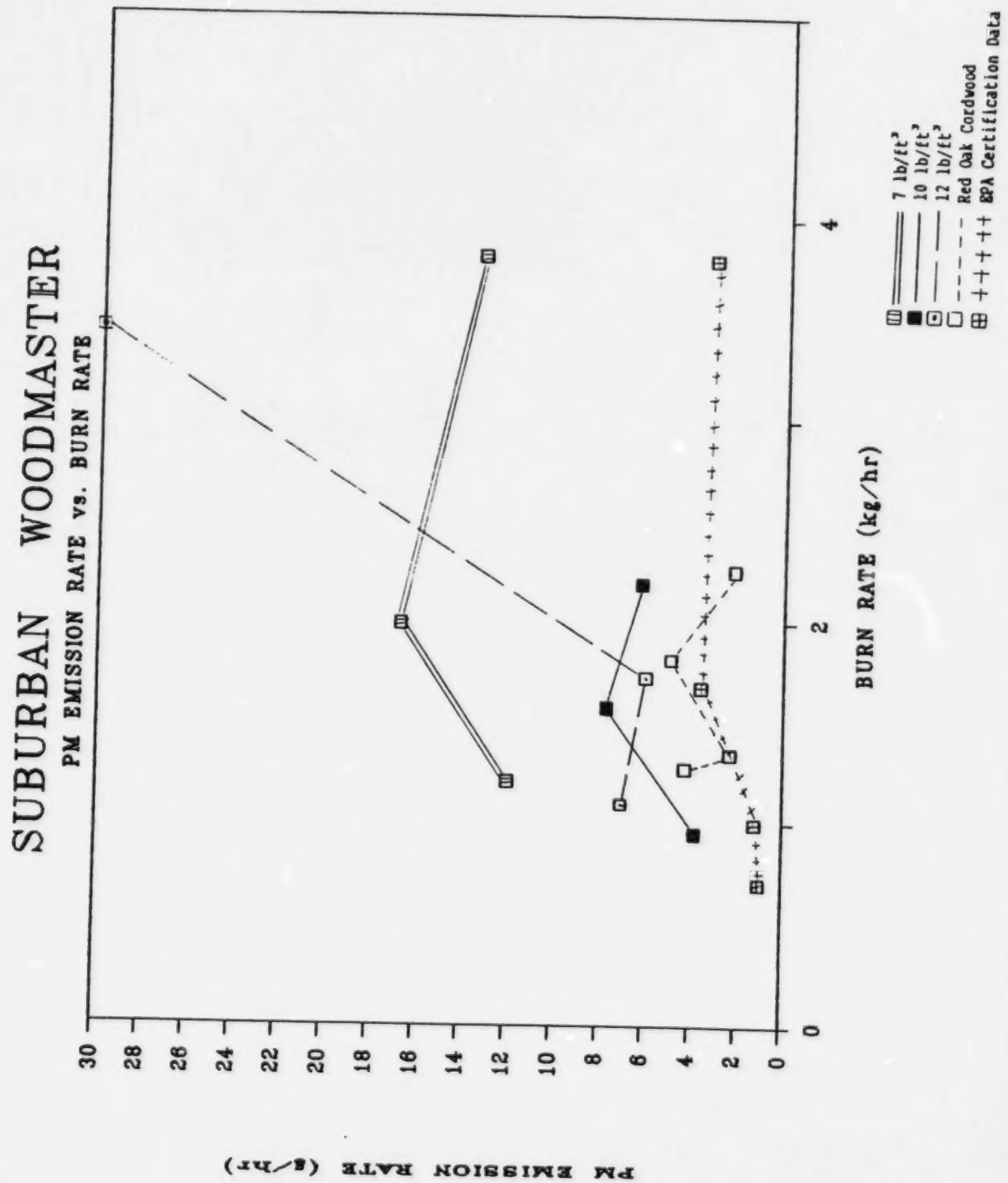
Weighted Average PM Emissions Rate: 19.4365 ÷ 1.4388 = 13.5088 g/hr
Weighted Average CO Emissions Rate: 129.9 ÷ 1.4388 = 90.3 g/hr
Weighted Average Overall Heating Efficiency: 105.89 ÷ 1.4388 = 73.60%

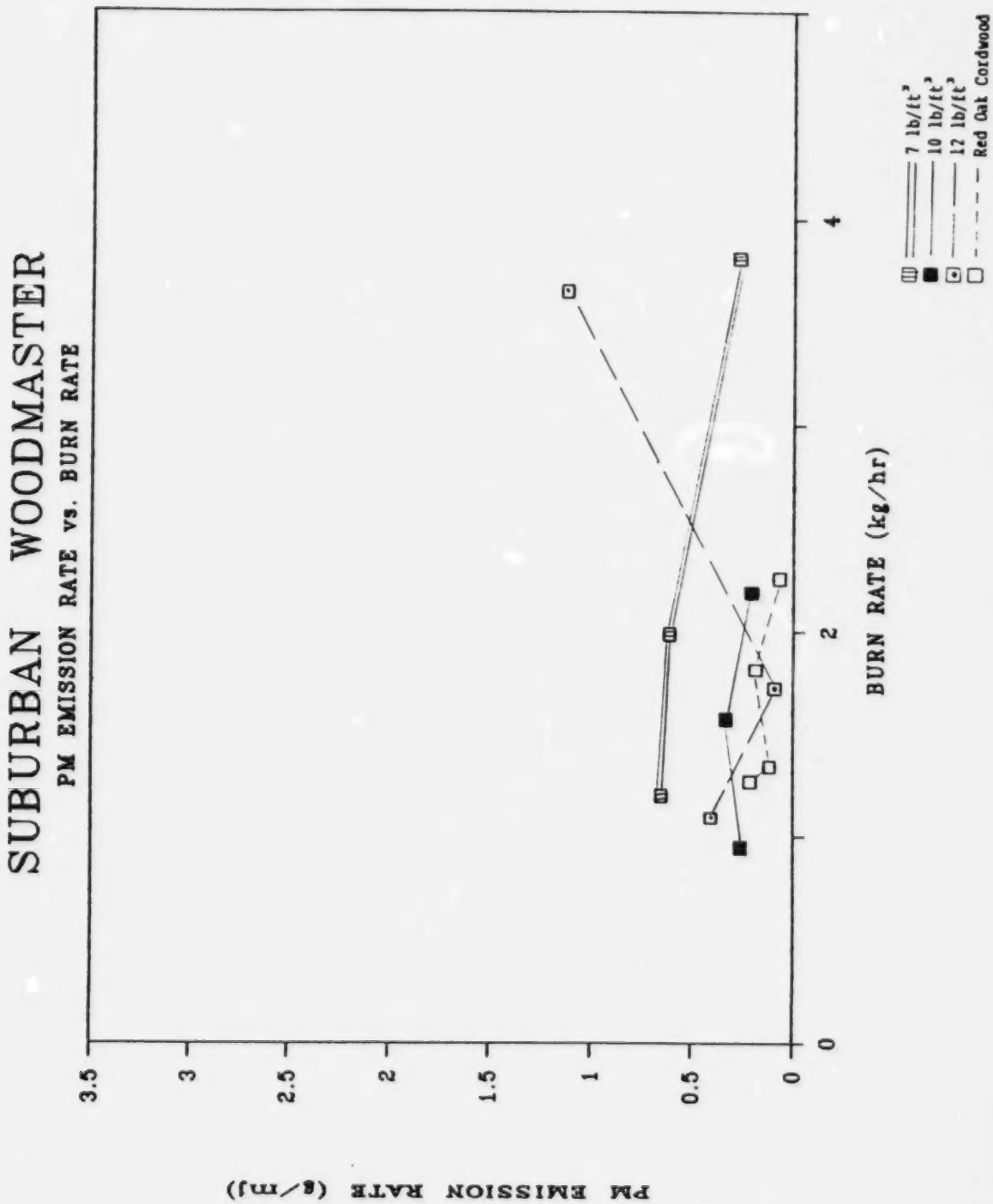
* Calculated as specified in CSA B-415

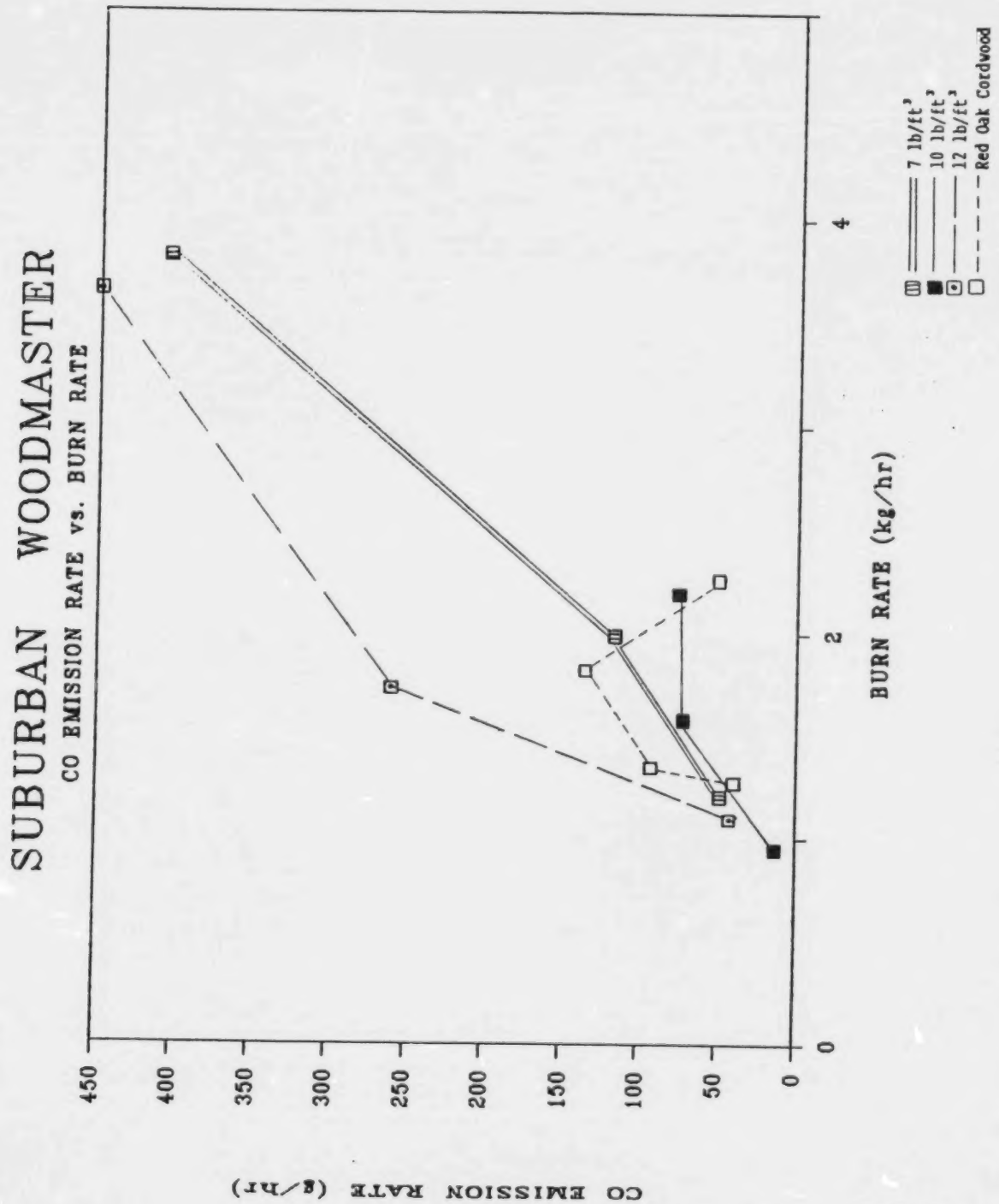
TABLE 3

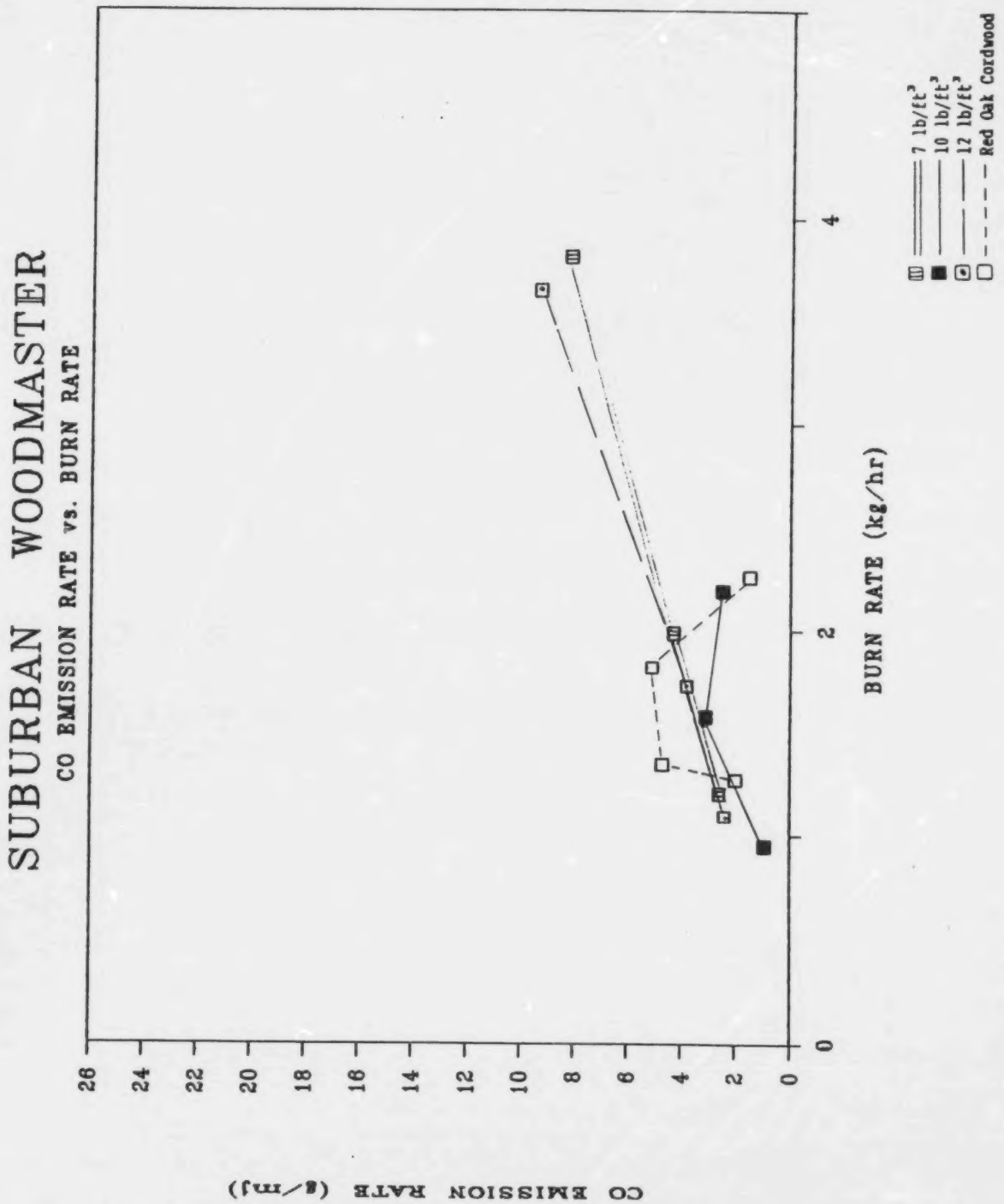
SUBURBAN MODEL: WOODMASTER

LOAD TYPE	RUN NUMBER	BURN RATE	EMISSION RATE CO g/hr	EMISSION RATE PM g/hr	CO g/mj	PM g/mj	EFFICIENCIES Combustion	EFFICIENCIES Heat Transfer	EFFICIENCIES Overall	DENSITY lb/ft	MOISTURE CONTENT
10 LB/FT	1	2.19	75.3	6.211	2.5	0.207	95.52	72.19	68.96	10.43	20.18
	2	0.95	12.7	3.812	0.9	0.259	95.02	81.66	77.60	9.99	21.61
	8	1.58	72.3	7.678	3.1	0.333	94.06	78.09	73.45	10.09	20.48
12 LB/FT	6	1.10	41.9	7.030	2.4	0.406	95.45	82.79	79.03	11.49	21.57
	7	1.73	260.1	6.000	3.8	0.088	93.99	84.25	85.99	11.45	20.75
	11	3.65	449.6	54.280	9.3	1.120	84.32	77.67	65.49	12.02	20.86
RED OAK	3	2.26	50.1	2.180	1.5	0.067	98.21	74.52	73.19	8.51	22.09
CORDWOOD	4	1.82	135.4	4.920	5.1	0.184	92.12	79.98	73.68	8.43	22.03
	5	1.35	92.7	2.293	4.7	0.116	89.69	82.04	73.59	8.79	21.24
	10	1.28	39.8	4.280	2.0	0.213	96.33	81.61	78.62	8.12	21.92
7 LB/FT (EPA)	9	1.21	48.2	11.949	2.6	0.652	94.05	81.39	76.55	7.44	20.66
	2E	1.59	116.5	16.710	4.3	0.613	91.55	75.61	69.22	7.41	22.09
	3E	3.81	404.9	13.280	8.2	0.270	88.56	73.41	65.01	6.46	21.85
EPA	4	0.70		1.000						6.70	23.00
CERTIFICATION	1	1.00		1.200						7.00	23.00
DATA	3	1.60		3.600						7.00	23.00
	5	3.10		3.200						7.00	24.00

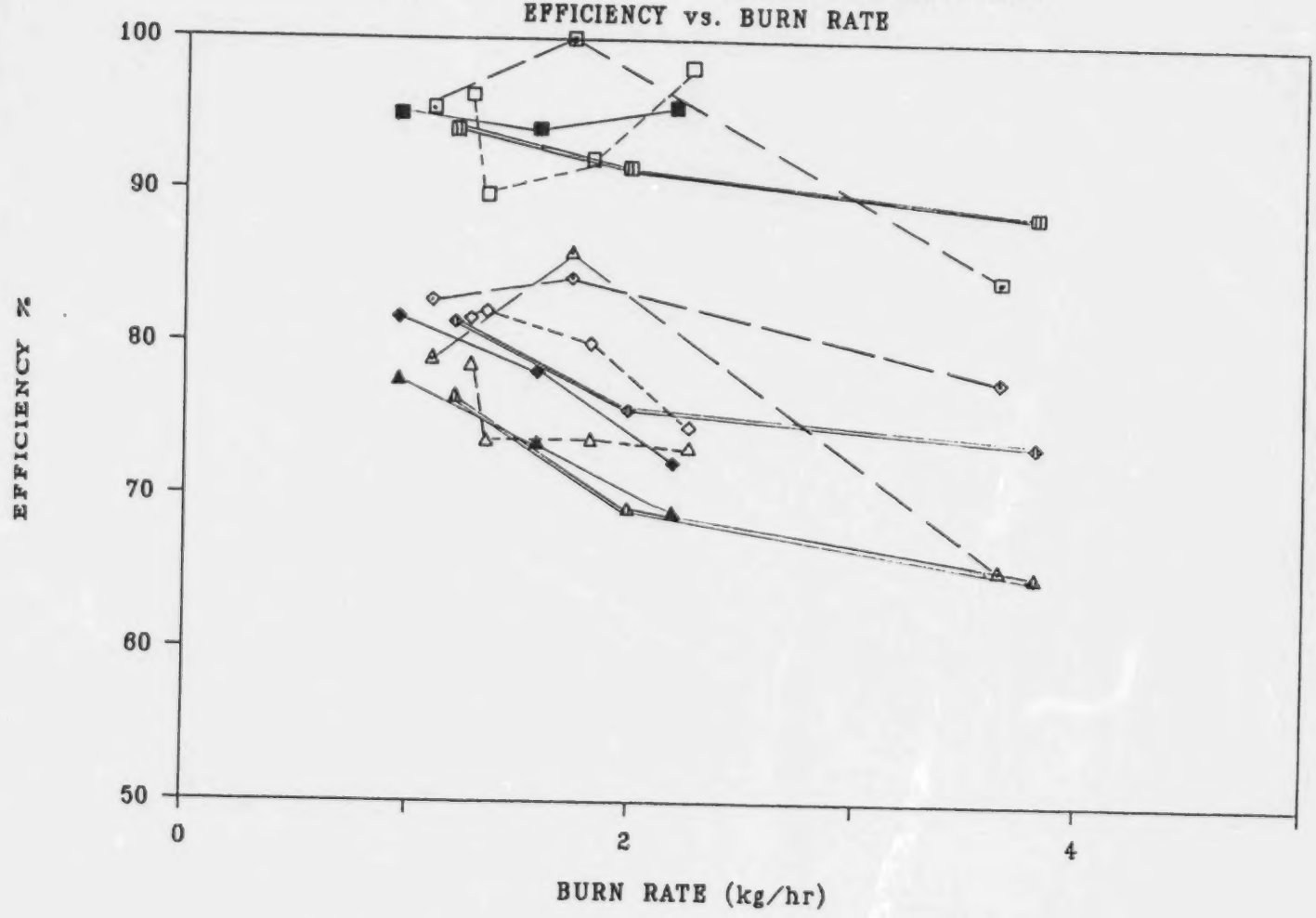

SUBURBAN WOODMASTER
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
2
4
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
EPA Certification Data


SUBURBAN WOODMASTER
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/mJ)
BURN RATE (kg/hr)
0
0.5
1
1.5
2
2.5
3
3.5
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


SUBURBAN WOODMASTER
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
50
100
150
200
250
300
350
400
450
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


SUBURBAN WOODMASTER
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/mJ)
BURN RATE (kg/hr)
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
0
2
4
6
8
10
12
14
16
18
20
22
24
26

SUBURBAN WOODMASTER



WARNOCK HERSEY INTERNATIONAL, INC. TEST REPORT #632-911300
FUEL LOADING DENSITY EFFECTS ON WOOD STOVE EMISSIONS RATES
PREPARED FOR: TECHNOLOGY BRANCH, ENERGY MINES AND RESOURCES
JUNE 1990

OBSERVATIONS continued

New Buck Carolina 41 CD

This unit produced relatively consistent results across the fuel types. Of interest is the apparent reversal of the normal trend of increasing emissions with increasing burn rate for catalytic stoves when cordwood was used. This may simply be due to a slower start up and catalyst light off when cordwood is used vs. the better ventilated and less dense Douglas Fir loads at low burn rates.

NEW BUCK CAROLINA 10 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
3	79.1	2.45	.4840	.8000	1.9568	74.02	59.22	63.3
6	151.0	5.91	.8000	.4328	2.5574	72.92	31.56	65.4
9	139.5	8.44	.9168	.1430	1.2069	69.30	9.91	19.9
7	150.6	11.30	.9430	.0832	.9401	70.99	5.91	12.5
Sums:				1.459	6.6612		106.59	161.1

Weighted Average PM Emissions Rate: 6.6612 ÷ 1.459 = 4.5656 g/hr
Weighted Average CO Emissions Rate: 161.1 ÷ 1.459 = 110.4 g/hr
Weighted Average Overall Heating Efficiency: 106.59 ÷ 1.459 = 73.06%

* Calculated as specified in CSA B-415

NEW BUCK CAROLINA 12 LB/FT^3
WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
2	88.9	3.96	.5588	.8820	3.4883	72.70	64.12	78.4
1	153.8	9.06	.8820	.3704	3.3566	70.96	26.28	56.9
4	164.0	7.18	.9292	.1180	.8467	70.70	8.34	19.4
Sums:				1.3704	7.6915		98.75	154.7

Weighted Average PM Emissions Rate: 7.6915 ÷ 1.3704 = 5.6126 g/hr
Weighted Average CO Emissions Rate: 154.7 ÷ 1.3704 = 112.9 g/hr
Weighted Average Overall Heating Efficiency: 98.75 ÷ 1.3704 = 72.06%

* Calculated as specified in CSA B-415

NEW BUCK CAROLINA RED OAK CORDWOOD

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
11	106.7	8.78	.5588	.7166	6.2946	68.28	48.93	76.5
10	103.4	6.79	.7166	.3284	2.2282	70.92	23.29	34.0
13	137.5	5.76	.8872	.2834	1.6324	66.61	18.88	38.9
Sums:				1.3284	10.1552		91.10	149.4

Weighted Average PM Emissions Rate: 10.1552 ÷ 1.3284 = 7.6447 g/hr
Weighted Average CO Emissions Rate: 149.4 ÷ 1.3284 = 112.5 g/hr
Weighted Average Overall Heating Efficiency: 91.10 ÷ 1.3284 = 68.58%

* Calculated as specified in CSA B-415

NEW BUCK CAROLINA EPA 7 LB/FT^3

WEIGHTED AVERAGE CALCULATION

Run Number	CO (g/hr)	Adjusted Emission Rate (E) (g/hr)	Cumulative Probability	Weighing Factor (K)	K x E (g/hr)	Overall Heating Efficiency* (%) (OHE)	K x OHE (%)	K x CO (g/hr)
8	80.2	5.702	.6268	.8792	5.0132	76.15	66.95	70.5
1E	173.4	12.050	.8792	.3388	4.0825	70.25	23.80	58.7
2E	220.1	21.412	.9656	.1208	2.5866	69.57	8.40	26.6
Sums:				1.3388	11.6823		99.16	155.8

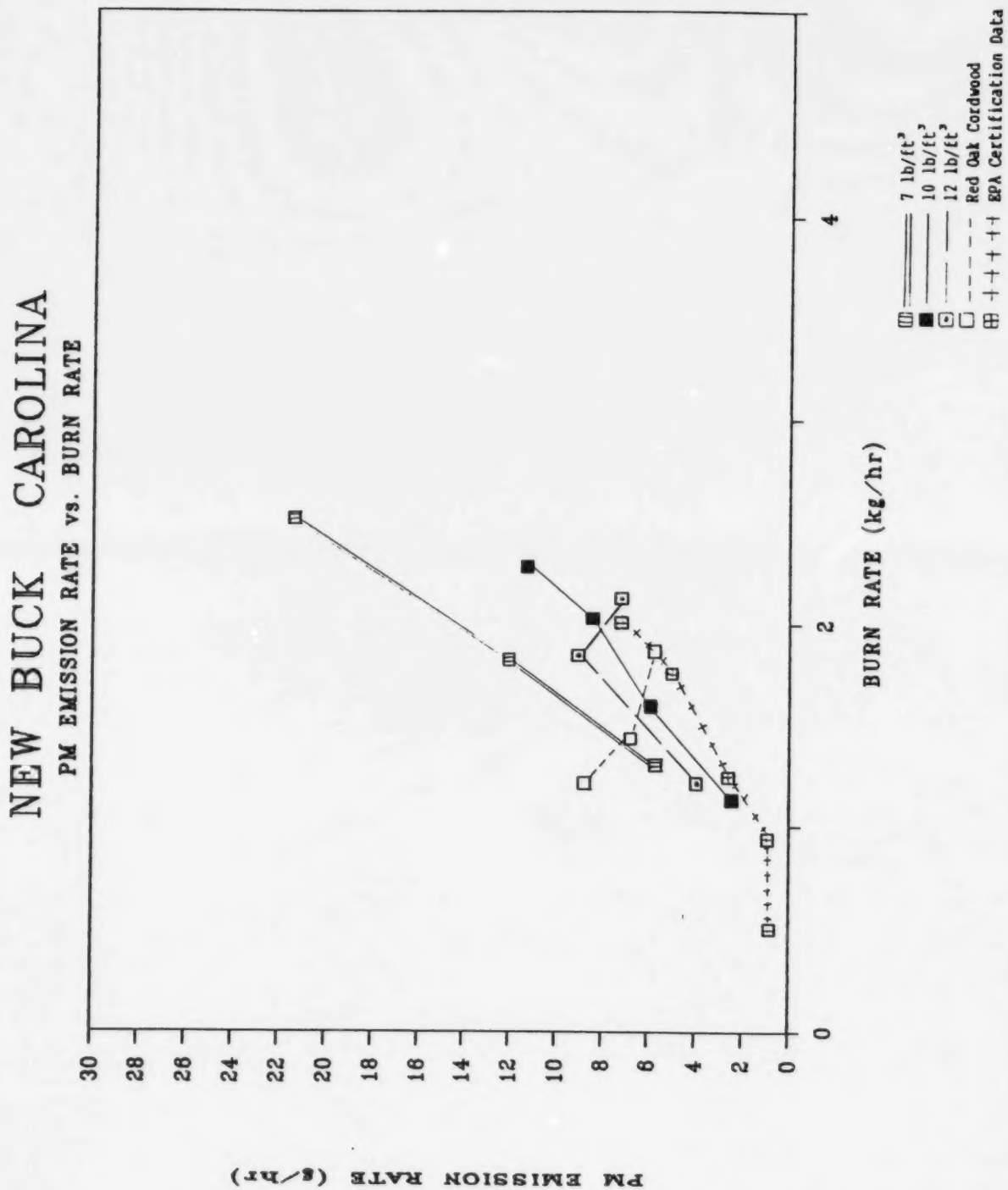
Weighted Average PM Emissions Rate: 11.6823 ÷ 1.3388 = 8.7260 g/hr
Weighted Average CO Emissions Rate: 155.8 ÷ 1.3388 = 116.4 g/hr
Weighted Average Overall Heating Efficiency: 99.16 ÷ 1.3388 = 74.06%

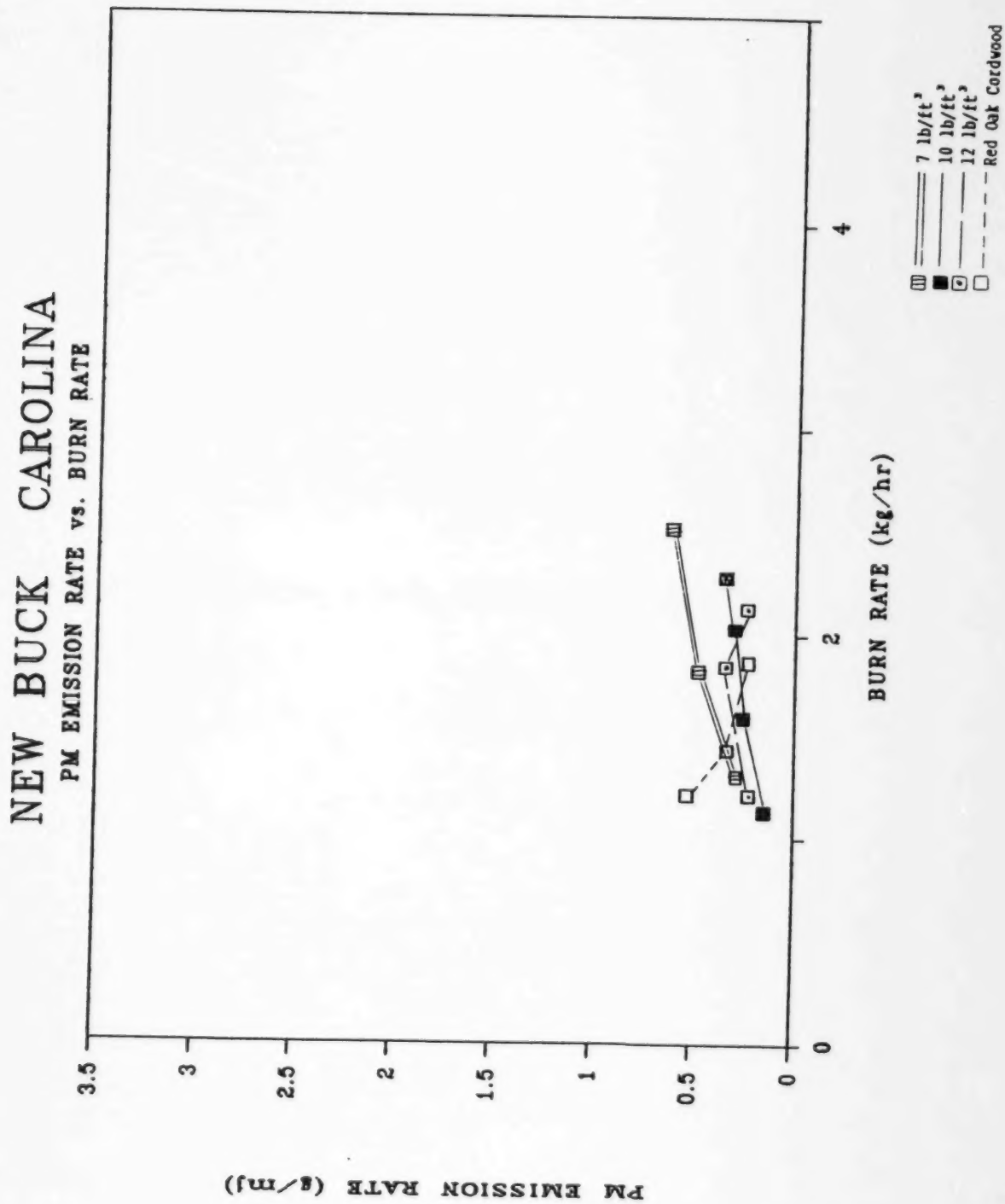
* Calculated as specified in CSA B-415

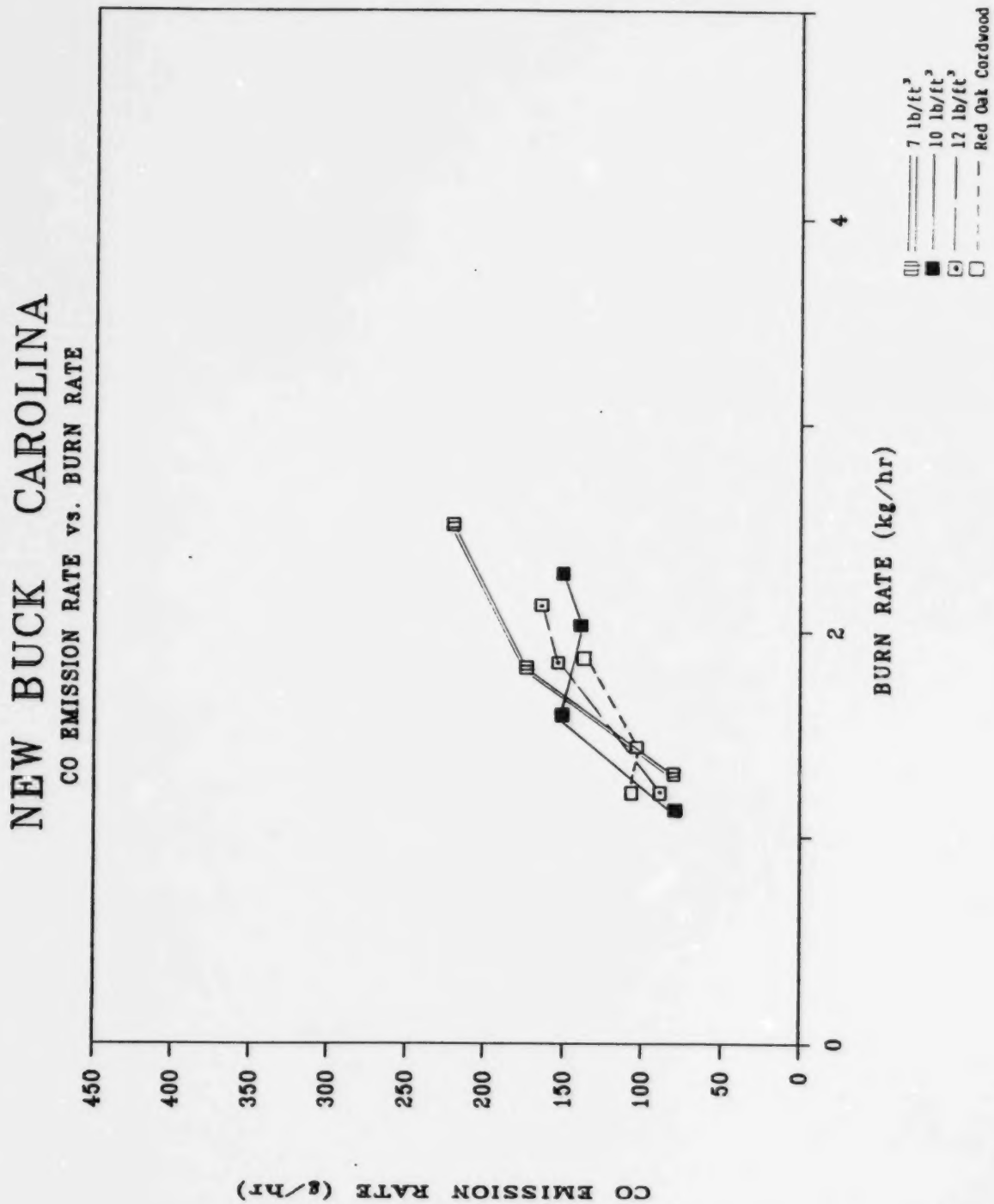
TABLE 1

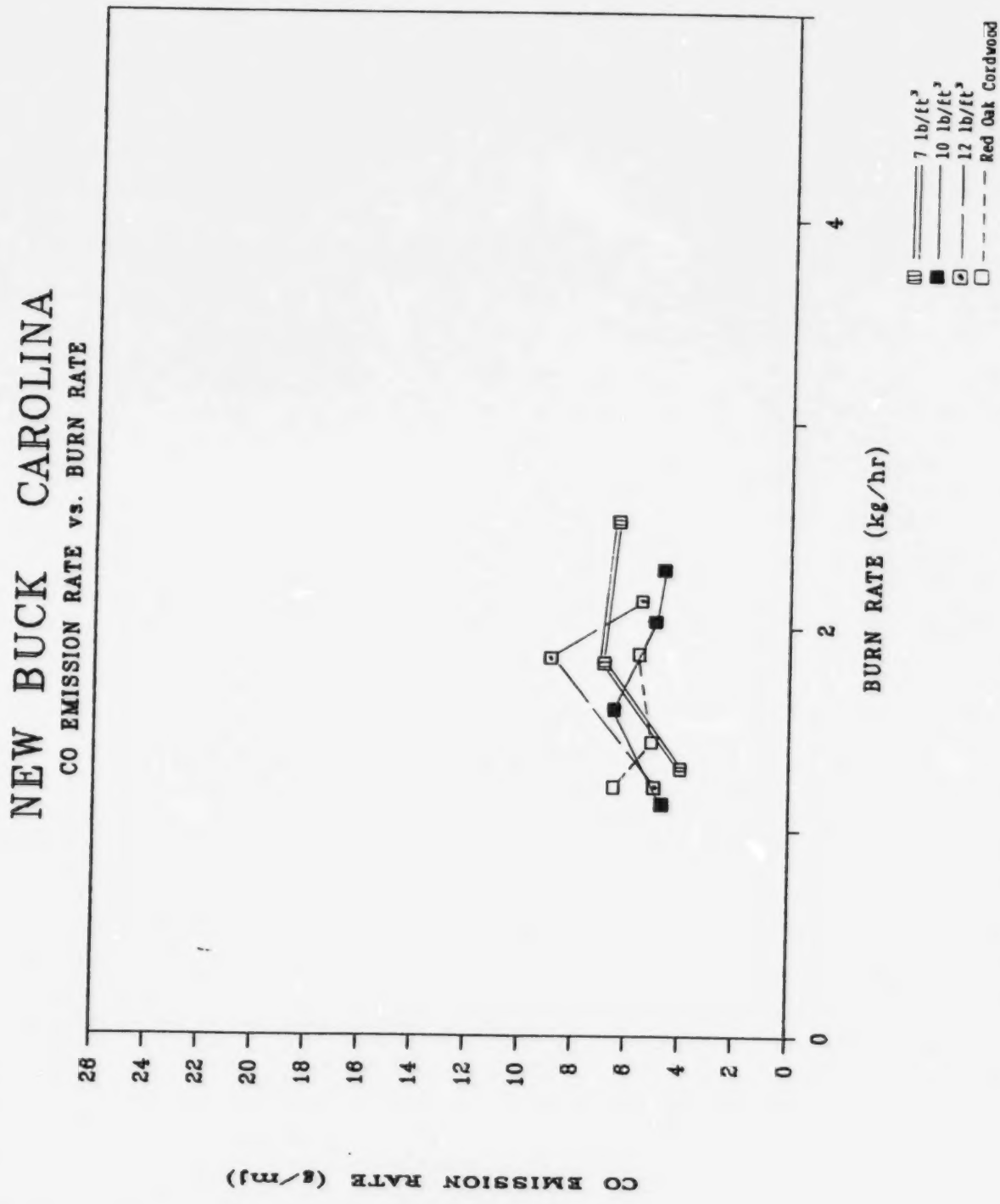
NEW BUCK MODEL: CAROLINA

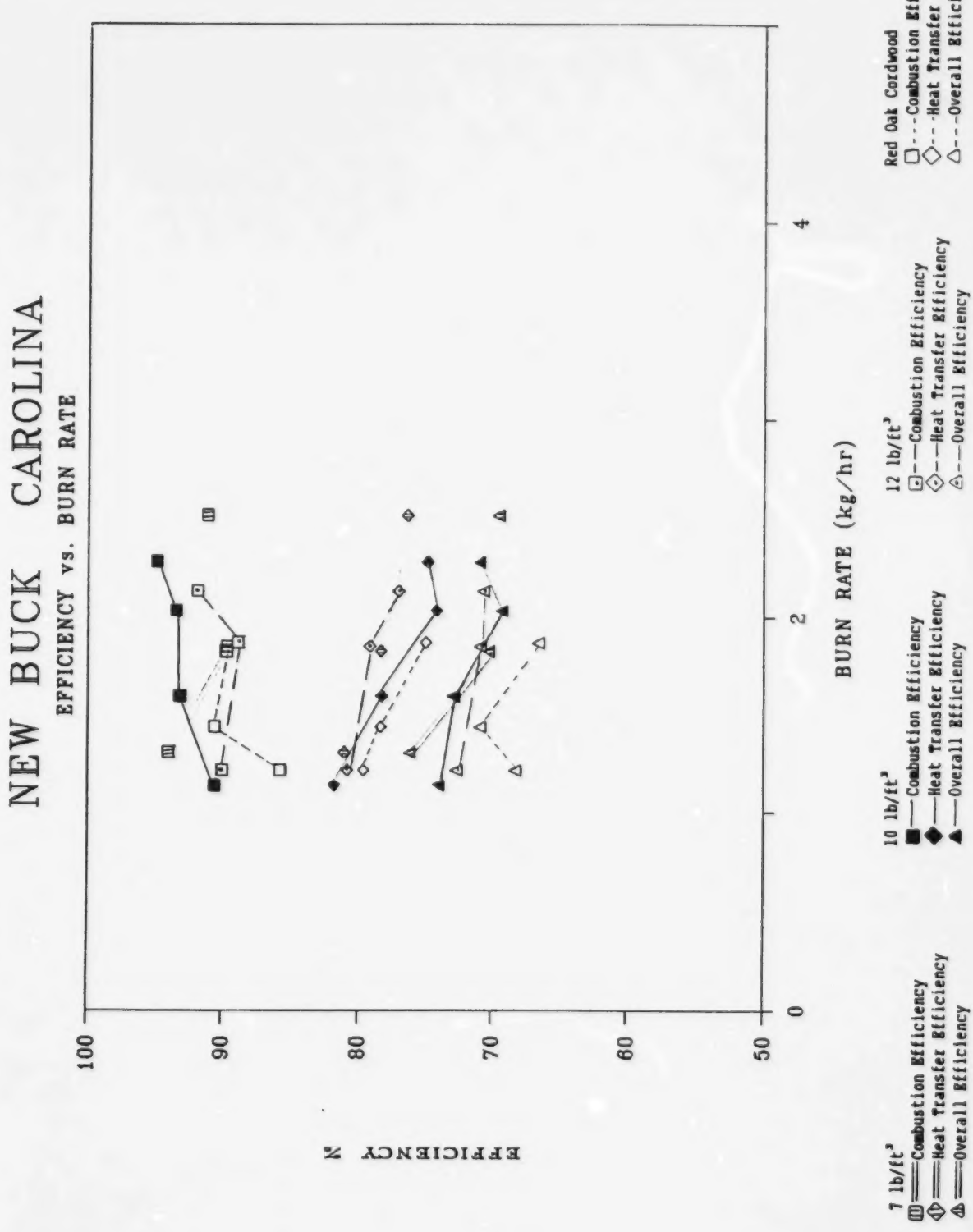
LOAD TYPE	RUN NUMBER	BURN RATE	EMISSION RATE CO g/hr	EMISSION RATE PM g/hr	EMISSION RATE CO g/mj	EMISSION RATE PM g/mj	EFFICIENCIES Combustion	EFFICIENCIES Heat Transfer	EFFICIENCIES Overall	DENSITY lb/ft	MOISTURE CONTENT
10 LB/FT	3	1.14	79.1	2.446	4.7	0.146	90.52	81.77	74.02	10.33	22.29
	6	1.60	151.0	5.909	6.5	0.254	93.15	78.28	72.92	10.36	22.50
	7	2.28	150.6	11.299	4.7	0.352	94.85	74.84	70.99	10.21	22.58
	9	2.03	139.5	8.440	5.0	0.301	93.44	74.17	69.30	9.90	22.86
12 LB/FT	1	1.85	153.8	9.062	8.9	0.348	89.65	79.15	70.96	12.15	20.32
	2	1.22	88.9	3.955	5.0	0.224	89.59	80.78	72.70	12.03	20.74
	4	2.13	164.0	7.175	5.5	0.239	91.82	76.99	70.70	11.89	22.08
RED OAK	10	1.44	103.4	6.785	5.1	0.333	90.52	78.35	70.92	10.59	20.36
CORDWOOD	11	1.22	106.7	8.784	6.5	0.531	85.77	79.60	68.28	10.46	20.15
	13	1.87	137.5	5.760	5.6	0.233	88.87	74.96	66.61	10.63	21.05
7 LB/FT (EPA)	8	1.31	80.2	5.702	4.0	0.288	93.59	81.01	76.15	7.15	21.42
	18	1.83	173.4	12.050	6.9	0.480	89.69	78.32	70.25	7.00	20.18
	28	2.52	220.1	21.412	6.4	0.622	91.12	76.35	69.57	7.32	20.96
EPA	5	0.50		0.800						6.90	22.00
CERTIFICATION	2	0.94		0.900						7.40	22.00
DATA	3	1.25		2.600						7.10	22.00
	6	1.76		5.000						7.10	21.00
	1	2.01		7.200						7.20	22.00


NEW BUCK CAROLINA
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
2
4
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood
EPA Certification Data


NEW BUCK CAROLINA
PM EMISSION RATE vs. BURN RATE
PM EMISSION RATE (g/mj)
BURN RATE (kg/hr)
0
0.5
1
1.5
2
2.5
3
3.5
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


NEW BUCK CAROLINA
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/hr)
BURN RATE (kg/hr)
0
50
100
150
200
250
300
350
400
450
0
2
4
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


NEW BUCK CAROLINA
CO EMISSION RATE vs. BURN RATE
CO EMISSION RATE (g/mj)
BURN RATE (kg/hr)
0
2
4
0
2
4
6
8
10
12
14
16
18
20
22
24
28
7 lb/ft³
10 lb/ft³
12 lb/ft³
Red Oak Cordwood


NEW BUCK CAROLINA
EFFICIENCY vs. BURN RATE
EFFICIENCY %
BURN RATE (kg/hr)
100
90
80
70
60
50
0
2
4
7 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
10 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
12 lb/ft³
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency
Red Oak Cordwood
Combustion Efficiency
Heat Transfer Efficiency
Overall Efficiency

ANALYSIS

Statistical tests on the results show no significant relationship between emission rates and fuel loading. In almost all cases the variability in emissions rates appears to be as large within a fuel type as it is between fuel types. The one exception is the Suburban Woodmaster stove which did show significantly higher emissions using the 7 lb/ft^3 EPA fuel load. This indicates that some stove designs may indeed be sensitive to dramatic fuel configuration differences. However, it is difficult to rationalize this observation with the much lower emissions using the same fuel load achieved in certification tests.

It should be noted that the fuel load variations involved were not as broad as will occur in the field. The basic dimensions of all fuel pieces were in a narrow range and the moisture content of the fuel was consistent throughout the project. Coal bed size and preparation was also consistent as well as reloading and start-up procedures. These parameters are all likely to be important variables in field performance and the potential of large variations in field emissions performance should therefore not be discounted.

The data does not indicate that the tight control of fuel load geometry is as critical to reproducible results as has been assumed by the standards developers. In none of the stoves tested did the relative randomness implied by cordwood loading result in a measurable difference in emissions performance from that obtained using tightly specified loading procedures. This may be a highly significant conclusion in terms of testing costs and interpretations. Under the current EPA regulations, a significant number of otherwise valid tests are discarded due to minor differences in firebox volume determinations between the laboratories and EPA. The data generated in this project would suggest that the tight tolerances of load weight per stove volume are not necessary to achieve representative test results.

ANALYSIS continued

An additional concern in this area is the expense and difficulty associated with using Douglas Fire dimensional lumber for fuel. Douglas Fir is a premium quality lumber which commands relatively high prices. Since virtually all supplies come from the West Coast, its availability in Eastern Canada and the U.S. is limited. The results of this project suggest that use of other species would be unlikely to affect test results. As a practical matter, a relaxation in fuel requirements would not meet the goal harmonizing CSA B415 with the U.S. EPA regulations. Thus a change in this area would only benefit manufacturer's not interested in gaining emissions certifications in both countries based on a single test program. Unless the U.S. EPA amends its test procedures, it is reasonable to expect most tests will be conducted using the EPA fuel specifications.

CONCLUSIONS

1. All units tested exhibited about as much variation in emission performance within a fuel type as was shown between fuel types.

2. Based on weighted average emissions rates, no significant differences in performance were observed based on fuel loading parameters investigated.

3. All units showed emissions rates above certification levels. This is no doubt a result of combined factors which include normal variability in production, differences in laboratory procedures, optimum conditions, and tight control of all aspects of unit operation during certification testing.

4. Fuel loading specifications do not appear to require as tight control as has been in common practice in order to achieve reproducible results.

5. Some appliance designs appear to be less variable in performance than others, irrespective of fuel loading parameters.

6. Fuel parameters such as moisture content, major variations in piece size, coal bed conditions, etc., may result in substantial performance variations and were not part of this investigation.

7. Since procedures and unit operation are normally optimized for certification tests, it is likely that emissions rates measured in field studies will be higher than the laboratory results. The data obtained in this study showed increases from certified rates of as much as 300% and as little as 10%. We could find no reliable indicators in the certification data which could predict high or low variability in the performance of a particular stove design.

CONCLUSIONS continued

8. Only one unit showed performance using the EPA fuel load which met EPA certification criteria. Since all units involved were originally certified at other laboratories, this may indicate a potential problem in interlaboratory reproducibility of test results. It is unknown and cannot be determined from this program how much of the variability is due to each of the following factors.

   a. Physically different stove.
   b. Method differences allowed under the EPA regulation.
   c. Differences in stove operation, start-up, etc.
   d. Inherent variability in emissions performance.

9. The cordwood loadings were all in a range from 8.12 to 10.86 lb/ft^3. No difficulty was experienced in loading the cordwood or the B-415 loads. In some designs the EPA loads are very "tight" and loading was sometimes very difficult.

10. If one considers the extremes in terms of fuel loadings investigated here (with 7 lb/ft^3 EPA fuel being one extreme and Oak Cordwood the other) only the Suburban Woodmaster show a substantial difference in particulate emissions and only the Sweet Home AFX-HT shows a difference in Carbon Monoxide emissions.

Report prepared and written by:

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Manager U.S. Central Region

SUMMARY OF TEST RESULTS / REGENCY LARGE

EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	CO Emission (g/hr)	Emission Rate (g/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency** (% Overall)
2	5/10/89	2.20	213.7	12.019	14.334	69.37
3	5/12/89	1.89	181.3	9.056	11.332	71.37
5	5/19/89	.87	257.8	18.906	20.876	65.26
7	6/19/89	4.24	179.6	5.841	7.874	56.99
1	5/10/89	3.35	171.3	2.908	4.4132	54.6
4	5/22/89	1.51	227.5	21.689	23.3961	69.05
8	6/20/89	1.11	201.8	7.980	10.2033	70.14
11	8/22/89	2.43	200.7	1.487	2.527	50.23
12	8/23/89	.753	178.2	26.848	27.930	54.42
13	8/24/89	1.66	146.0	1.193	2.106	65.4
10	6/22/89	1.11	225.8	20.348	22.187	70.58
1E	3/21/90	4.19	58.6	1.913	3.115	63.64
2E	3/22/90	1.51	211.5	7.3048	9.4807	69.98

** Calculated as specified in CSA B-415

TEST FACILITY CONDITIONS REGENCY R6

Run Number	Room Temperature (°F)		Barometric Pressure (in. Hg)		Relative Humidity (%)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After	Before	After
2	71	74	29.31	29.20	39	35	0	0
3	71	73	29.10	29.02	38	35	0	0
5	74	73	28.90	28.80	58	60	0	0
7	82	86	29.11	29.11	60	43	0	0
1	75	75	29.28	29.28	34	28	0	0
4	75	78	29.10	28.96	52	49	0	0
6	76	76	29.00	28.98	54	46.5	0	0
8	79	81	29.14	29.06	54	46	0	0
11	83	86	28.90	28.90	64	59	0	17
12	77	76	29.08	29.08	67	64	0	19
13	78	79	29.19	29.17	65	56	0	10
10	81	83	29.00	29.00	58	53	0	0
1E	72	74	29.08	29.05	40	35	0	0
2E	73	70	28.93	29.05	48	44	0	0

FUEL QUALITIES REGENCY R6

Run Number	Pre-Test Load			Test Load					
	Weight Wet Basis (lb)	Moisture Content Dry Basis (%)	Coal Bed Weight (lb)	Weight Wet Basis (lb)	Loading Density Wet Basis (lbs/ft^3)	Moisture Content Dry Basis (%)	Piece Length (in.)	Number of 2x4's	Number of 4x4's
2	17.84	20.00	2.8	21.86	9.94	21.32	18.5	4	3
3	20.24	22.67	2.8	22.70	10.41	21.52	18.5	4	3
5	17.82	23.12	2.8	21.62	9.92	23.05	18.5	4	3
7	19.95	21.46	2.8	21.73	9.97	22.32	18.5	4	3
1	20.6	22.99	3.4	26.18	12.00	22.96	18.5	4	3
4	20.30	22.70	3.4	26.91	11.98	21.76	18.5	4	3
6	21.06	22.07	3.4	26.24	12.04	23.61	18.5	4	3
8	20.28	22.70	3.6	26.41	12.11	22.92	18.5	4	3
11	16.89	22.69	2.6	20.38	9.34	20.7	N/A	N/A	N/A
12	16.52	22.44	2.6	19.56	8.97	22.63	N/A	N/A	N/A
13	15.71	19.31	2.5	18.92	8.68	22.35	N/A	N/A	N/A
10	14.52	23.30	2.9	14.28	6.55	22.895	18.5	2	2
1E	16.50	21.29	3.0	14.70	6.56	20.73	18.5	2	2
2E	14.19	21.71	3.6	14.69	6.74	20.33	18.5	2	2

DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA (5G-3) REGENCY R6

Run Number	Burn Time (min)	Average Dilution Tunnel Measurements			Sample Data			
		Velocity (ft/sec)	Volumetric Flow Rate (dscf/min)	Temperature (°R)	Total Sample Volume (dscf)		Particulate Catch (mg)	
					1	2	1	2
2	223	13.81	142.589	564.958	53.03	52.53	74.7	73.6
3	269	13.48	138.411	564.037	63.45	63.28	70.3	67.9
5	550	12.79	135.817	541.732	129.12	128.40	313.2	294.3
7	114	16.35	148.72	637.692	26.68	26.63	16.8	18.1
1	173	16.80	158.987	616.632	40.70	40.32	12.9	11.8
4	311	13.63	141.049	559.303	72.98	72.57	84.4	83
6	387	12.81	134.239	551.600	90.81	90.34	244.6	243.2
8	525	13.23	138.440	554.352	123.34	122.83	118.9	117.6
11	187	18.287	175.330	600.850	44.16	44.28	7.1	5.4
12	568	13.968	148.619	544.793	104.09	100.42	309.1	306.5
13	254	14.255	148.099	559.852	59.85	60.11	8.60	7.5
10	284	13.583	141.194	556.100	66.64	66.43	160.4	159.2
1E	77	16.374	149.262	635.556	18.04	18.00	4.3	3.4
2E	220	13.592	141.664	554.435	51.40	51.25	44.4	43.8

DILUTION TUNNEL DUAL TRAIN PRECISION REGENCY R6

Run Number	Sample Ratios		Total Emissions (grams)		% Deviation
	Train 1	Train 2	Train 1	Train 2	
2	599.57	605.33	44.79	44.55	.218
3	586.77	588.40	41.25	39.95	1.326
5	578.51	581.76	175.40	171.21	1.003
7	635.39	636.55	10.67	11.52	3.168
1	675.81	682.13	8.72	8.15	3.31
4	601.08	604.43	50.73	50.18	.463
6	572.06	575.07	139.92	139.86	.002
8	589.28	591.73	70.07	69.59	.284
11	742.41	740.47	5.271	3.998	11.417
12	810.98	840.62	250.68	257.65	1.139
13	628.50	625.77	5.41	4.69	5.854
10	601.72	603.58	96.52	96.09	.183
1E	637.09	638.38	2.74	2.17	9.632
2E	606.38	608.14	26.92	26.64	.444

GENERAL SUMMARY OF RESULTS REGENCY R6

Run Number	Burn Rate (kg/hr)	Change In Surface Temperature (^{0}F)	Initial Draft (in. H_2O)	Primary Air Setting	Run Time (min)	Average Draft (in. H_2O)
2	2.20	10.6	.064	6.4 cm	223	.095
3	1.89	33.6	.062	6.0 cm	269	.072
5	.87	77.4	.039	3.0 cm	550	.044
7	4.24	10.8	0.81	full open	114	.090
1	3.35	139.6	.086	full open	173	.090
4	1.88	11.40	.060	5 cm	311	.068
6	1.51	99	.055	3.5 cm	387	.057
8	1.11	46.6	.038	3.2 cm	525	.048
11	2.43	122.8	.074	full open	187	.079
12	.753	26.2	.041	4 cm	568	.038
13	1.66	71.8	.052	6 cm	254	.065
10	1.11	99	.043	3.2 cm	284	.046
1E	4.19	111.6	.084	full open	77	.087
2E	1.51	72.4	.054	4 cm	220	.055

SUMMARY OF TEST RESULTS / SWEET HOME

EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	CO Emission (g/hr)	Emission Rate (g/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency** (% Overall)
1	6/27/89	1.28	153.7	6.068	8.129	72.35
4	6/30/89	2.74	69.6	1.946	3.162	73.53
6	7/6/89	1.12	165.2	8.566	10.821	69.19
2	6/28/89	2.93	81.1	5.260	7.321	71.62
3	6/29/89	1.16	144.8	5.105	7.042	73.72
5	7/5/89	1.48	137.2	6.180	8.253	72.43
8	8/17/89	2.35	324.8	2.896	4.399	67.31
9	8/18/89	1.05	201.6	9.946	12.250	71.64
10	8/21/89	1.43	155.2	1.932	3.145	76.26
7	7/7/89	1.32	109.9	5.309	7.274	72.10
1E	3/16/90	2.528	56.2	1.685	2.805	70.65
2E	3/19/90	1.475	110.1	7.364	9.545	70.13

** Calculated as specified in CSA B-415

TEST FACILITY CONDITIONS SWEET HOME AFX-HT

Run Number	Room Temperature (°F)		Barometric Pressure (in. Hg)		Relative Humidity (%)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After	Before	After
1	81	83	28.98	28.98	59	49.5	0	0
4	83	86	29.25	29.20	53.0	42.0	0	0
6	84	89	29.18	29.12	57.5	43.9	0	0
2	81	84	29.16	29.18	56	47	0	0
3	81	84	29.34	29.28	50	43	0	0
5	85	88	29.20	29.15	59	39	0	0
8	79	82	29.28	29.28	58	45.5	0	0
9	78	79	29.33	29.29	57	49	17	18
10	80	82	29.01	29.01	58	54	14	0
7	82	85	29.20	29.22	65.0	51.0	0	0
1E	73	74	28.71	28.71	50	44	0	0
2E	73	71	29.49	29.49	42	38	0	0

FUEL QUALITIES SWEET HOME AFX-HT

Run Number	Pre-Test Load			Test Load					
	Weight Wet Basis (lb)	Moisture Content Dry Basis (%)	Coal Bed Weight (lb)	Weight Wet Basis (lb)	Loading Density Wet Basis (lbs/ft^3)	Moisture Content Dry Basis (%)	Piece Length (in.)	Number of 2x4's	Number of 4x4's
1	14.56	21.84	2.3	17.23	10.26	21.26	15	2	4
4	14.81	23.26	2.3	17.22	10.25	22.19	15	2	4
6	13.77	22.07	2.3	17.57	10.46	22.08	15	2	4
2	15.74	21.73	2.6	20.29	12.07	23.09	15	2	4
3	17.20	21.47	2.6	20.08	11.95	21.62	15	2	4
5	15.77	21.20	2.5	20.46	12.18	23.55	15	2	4
8	10.33	23.01	1.9	14.39	8.56	20.60	N/A	N/A	N/A
9	8.66	24.39	1.8	14.02	8.35	21.94	N/A	N/A	N/A
10	9.54	23.13	1.9	14.11	8.40	21.07	N/A	N/A	N/A
7	15.53	2028	3.4	16.12	7.44	20.66	19	2	2
1E	15.21	20.67	2.5	11.24	6.89	20.99	15	2	2
2E	11.75	20.53	2.4	11.57	6.89	20.48	15	2	2

DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA (5G-3)
SWEET HOME AFX-HT

Run Number	Burn Time (min)	Average Dilution Tunnel Measurements			Sample Data			
		Velocity (ft/sec)	Volumetric Flow Rate (dscf/min)	Temperature (°R)	Total Sample Volume (dscf)		Particulate Catch (mg)	
					1	2	1	2
1	299	13.504	139.463	559.355	70.00	69.55	50.7	50.5
4	140	14.528	143.135	591.267	32.87	32.89	7.0	7.9
6	346	13.183	137.319	557.806	81.28	81.18	84.8	84.1
2	153	15.487	152.022	592.353	35.89	35.73	20.5	21.5
3	388	13.404	140.563	557.125	91.23	91.15	55.8	54.6
5	305	13.498	139.166	564.064	71.56	70.97	53.0	52.5
8	138	15.317	155.418	575.200	32.62	32.75	10.1	11.1
9	298	13.190	141.367	545.129	70.74	70.83	83	83
10	220	13.609	142.248	553.217	51.52	51.80	12.3	11.1
7	190	13.197	138.249	555.000	44.63	44.43	29.4	27.6
1E	100	14.285	140.285	582.727	23.21	23.27	4.8	4.5
2E	176	13.352	140.644	558.053	41.50	41.35	36.4	35.9

DILUTION TUNNEL DUAL TRAIN PRECISION SWEET HOME AFX-HT

Run Number	Sample Ratios		Total Emissions (grams)		% Deviation
	Train 1	Train 2	Train 1	Train 2	
1	595.729	599.575	30.20	30.28	.103
4	609.718	609.33	4.27	4.81	4.989
6	584.566	585.256	49.57	49.22	.295
2	648.047	651.031	13.285	13.997	2.167
3	597.799	598.326	33.357	32.669	.866
5	593.127	598.039	31.436	31.397	.005
8	657.539	654.837	6.641	6.679	.238
9	595.565	594.779	49.432	49.367	.005
10	607.410	604.122	7.471	6.706	4.48
7	588.517	591.258	17.302	16.319	2.429
1E	604.528	602.953	2.902	2.713	2.786
2E	596.456	598.65	21.711	21.492	.422

GENERAL SUMMARY OF RESULTS SWEET HOME AFX-HT

Run Number	Burn Rate (kg/hr)	Change In Surface Temperature (^{o}F)	Initial Draft (in. H_2O)	Primary Air Setting	Run Time (min)	Average Draft (in. H_2O)
1	1.28	61.2	.045	10.3 cm	229	.055
4	2.74	17.8	.074	full open	140	.081
6	1.12	4.4	.046	10.5 cm	346	.051
2	2.93	18.8	.076	full open	153	.083
3	1.16	76.6	.059	10.5 cm	388	.053
5	1.48	15.2	.056	10.2 cm	305	.060
8	2.35	45.8	.066	full open	138	.076
9	1.05	50.6	.04	10.4 cm	298	.049
10	1.43	63.0	.051	10.1 cm	220	.057
7	1.32	94.4	.043	10.5 cm	190	.054
1E	2.528	26.8	.080	full open	100	.084
2E	1.475	39.0	.072	10.1 cm	176	.069

SUMMARY OF TEST RESULTS / SUBURBAN WOODMASTER

EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	CO Emission (g/hr)	Emission Rate (g/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency** (% Overall)
1	8/28/89	2.19	75.3	4.388	6.211	68.96
2	8/29/89	.95	12.7	2.302	3.812	77.60
8	9/7/89	1.58	72.3	5.665	7.678	73.45
6	9/5/89	1.10	41.9	5.10	7.03	79.03
7	9/6/89	1.73	260.1	4.21	6.00	85.99
11	9/12/89	3.65	449.6	59.80	54.28	65.49
3	8/30/89	2.26	50.1	1.25	2.18	73.19
4	8/31/89	1.82	135.4	3.32	4.92	73.68
5	9/1/89	1.35	92.7	1.32	2.293	73.59
10	9/11/89	1.28	39.8	2.80	4.28	78.62
9	9/8/89	1.21	48.2	9.692	11.989	76.55
2E	3/28/90	1.987	116.5	14.461	16.713	69.22
3E	3/29/90	3.811	404.9	10.965	13.282	65.01

** Calculated as specified in CSA B-415

TEST FACILITY CONDITIONS SUBURBAN WOODMASTER

Run Number	Room Temperature (°F)		Barometric Pressure (in. Hg)		Relative Humidity (%)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After	Before	After
1	78	78	29.04	29.00	72	67	0	0
2	75	77	29.02	29.02	70	52	0	0
8	78	77	29.06	29.02	67	67	18	15
6	77	76	29.21	29.19	75	64	0	19
7	77	78	29.14	29.09	66	68	0	10
11	73	73	29.30	29.32	63	46	0	10
3	75	77	29.11	29.12	68	50	19	15
4	77	78	28.99	28.90	65	63	0	0
5	76	77	28.79	28.92	62	62	5	0
10	72	73	29.12	29.14	67	55	0	0
9	75	76	28.94	28.96	67	61	0	0
2E	723	71	29.35	29.31	36	35	0	0
3E	71	72	29.25	29.23	43	39	0	0

FUEL QUALITIES SUBURBAN WOODMASTER

Run Number	Pre-Test Load			Test Load					
	Weight Wet Basis (lb)	Moisture Content Dry Basis (%)	Coal Bed Weight (lb)	Weight Wet Basis (lb)	Loading Density Wet Basis (lbs/ft^3)	Moisture Content Dry Basis (%)	Piece Length (in.)	Number of 2x4's	Number of 4x4's
1	17.12	20.89	2.9	22.60	10.43	20.18	19	2	4
2	17.75	23.77	2.8	21.64	9.99	21.61	19	2	4
8	18.17	22.50	2.8	21.81	10.09	20.48	19	2	4
6	19.64	20.61	3.1	24.89	11.49	21.57	19.5	2	4
7	18.98	22.69	3.1	20.75	11.45	20.75	19.5	2	4
11	19.01	21.45	3.3	26.04	12.02	20.86	19.5	2	4
3	13.60	22.90	2.4	18.44	8.51	22.09	N/A	N/A	N/A
4	15.86	24.75	2.4	18.26	8.43	22.03	N/A	N/A	N/A
5	15.58	20.77	2.4	19.05	8.79	21.24	N/A	N/A	N/A
10	15.40	24.30	2.3	17.54	8.12	21.92	N/A	N/A	N/A
9	15.53	20.28	3.4	16.12	7.44	20.66	19	2	2
2E	14.60	21.91	3.3	16.04	7.41	22.09	19	2	2
3E	15.89	22.46	3.1	13.99	6.46	21.85	19	2	2

DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA (5G-3)
SURBURBAN WOODMASTER

Run Number	Burn Time (min)	Average Dilution Tunnel Measurements			Sample Data			
		Velocity (ft/sec)	Volumetric Flow Rate (dscf/min)	Temperature (°R)	Total Sample Volume (dscf) 1	Total Sample Volume (dscf) 2	Particulate Catch (mg) 1	Particulate Catch (mg) 2
1	230	15.011	152.985	567.583	54.22	53.91	26.2	25.5
2	504	13.595	144.915	542.654	118.68	118.62	33.5	33.0
8	307	13.614	142.577	552.625	72.24	72.27	48.1	47.6
6	502	12.989	138.765	544.808	118.561	118.561	72.2	73.0
7	323	13.152	137.690	554.353	75.898	75.830	39.0	38.3
11	160	14.905	152.015	572.824	38.029	38.570	235.6	266.8
3	182	15.322	156.816	567.050	42.98	43.14	5.9	5.5
4	223	13.602	141.613	554.167	52.23	52.34	20.2	20.6
5	313	13.285	139.675	547.061	72.97	72.30	11.2	11.7
10	304	13.632	145.286	544.812	72.28	72.08	23.2	23.2
9	297	13.244	140.275	544.000	69.90	70.18	81.0	80.3
2E	180	13.411	139.529	561.947	42.25	42.28	73.4	72.6
3E	82	19.085	193.383	575.200	19.29	19.22	18.7	17.7

DILUTION TUNNEL DUAL TRAIN PRECISION SUBURBAN WOODMASTER

Run Number	Sample Ratios		Total Emissions (grams)		% Deviation
	Train 1	Train 2	Train 1	Train 2	
1	648.914	652.688	17.002	16.644	.883
2	615.408	615.708	20.616	20.318	.604
8	605.909	605.697	29.144	28.831	.448
6	587.55	587.55	42.42	42.89	.457
7	585.97	586.49	22.85	22.46	.715
11	635.57	626.66	149.74	167.19	4.57
3	664.109	661.586	3.918	3.639	3.070
4	604.620	603.390	12.21	12.43	.729
5	599.103	604.641	6.71	7.07	2.19
10	611.044	612.712	14.18	14.21	.113
9	596.054	593.661	48.280	47.671	.527
2E	594.513	594.083	43.637	43.130	.485
3E	821.878	824.964	15.369	14.602	2.125

GENERAL SUMMARY OF RESULTS SUBURBAN WOODMASTER

Run Number	Burn Rate (kg/hr)	Change In Surface Temperature (^{o}F)	Initial Draft (in. H_2O)	Primary Air Setting	Run Time (min)	Average Draft (in. H_2O)
1	2.19	81.4	.071	full open	230.	.074
2	.95	61.2	.030	3 cm	504	.048
8	1.58	45.2	.040	2.25 cm	307	.058
6	1.10	66.4	.042	2.75 cm	502	.048
7	1.73	8.0	.050	2.25 cm	323	.062
11	3.65	30.6	.073	full open	160	.075
3	2.26	21.4	.067	full open	182	.072
4	1.82	78.4	.057	2 cm	223	.059
5	1.35	8.6	.045	2.50 cm	313	.052
10	1.28	.2	.047	2.75 cm	304	.050
9	1.21	18.4	.049	2.75 cm	297	.051
2E	1.987	35.8	.058	2 cm	180	.062
3E	3.811	14.4	.075	full open	82	.077

SUMMARY OF TEST RESULTS / BUCK CAROLINA

EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	CO Emission (g/hr)	Emission Rate (g/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency** (% Overall)
3	8/3/89	1.14	79.1	1.428	2.446	74.02
6	8/8/89	1.60	151.0	4.132	5.909	72.92
7	8/9/89	2.28	150.6	9.024	11.299	70.99
9	8/11/89	2.03	139.5	6.350	8.440	69.30
1	8/1/89	1.85	153.8	6.917	9.062	70.96
2	8/2/89	1.22	88.9	2.547	3.955	72.7
4	8/4/89	2.13	164.0	5.221	7.175	70.7
10	8/14/89	1.44	103.4	4.881	6.785	70.92
11	8/15/89	1.22	106.7	6.663	8.784	68.28
13	8/16/89	1.87	137.5	4.011	5.760	66.61
8	8/10/89	1.31	80.2	3.958	5.702	76.15
1E	3/13/90	1.827	173.4	9.752	12.051	70.25
2E	3/14/90	2.515	220.1	19.493	21.412	69.57

** Calculated as specified in CSA B-415

TEST FACILITY CONDITIONS NEW BUCK CAROLINA

Run Number	Room Temperature (°F)		Barometric Pressure (in. Hg)		Relative Humidity (%)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After	Before	After
3	86	86	28.93	28.88	60	53	0	19
6	78	81	29.09	29.04	57	50	0	18
7	80	83	29.17	29.17	58	45	32	31
9	80	85	29.30	29.29	60	54	0	0
1	84	86	29.24	29.20	55	48	10	10
2	84	86	29.19	29.07	55	47	20	20
4	88	90	28.76	28.80	62	58	0	0
10	79	81	29.00	29.00	61	59	22	20
11	79	78	29.02	29.04	58	54	14	12
13	84	82	29.11	29.11	48	43	0	0
8	82	83	29.25	29.22	59	51	0	0
1E	74	76	29.07	28.98	65	58	0	0
2E	76	80	28.78	28.72	65	59	0	0

FUEL QUALITIES NEW BUCK CAROLINA

Run Number	Pre-Test Load: Weight Wet Basis (lb)	Pre-Test Load: Moisture Content Dry Basis (%)	Pre-Test Load: Coal Bed Weight (lb)	Test Load: Weight Wet Basis (lb)	Test Load: Loading Density Wet Basis (lbs/ft³)	Test Load: Moisture Content Dry Basis (%)	Test Load: Piece Length (in.)	Test Load: Number of 2X2's	Test Load: Number of 4x4's
3	14.89	21.92	2.6	19.54	10.33	22.29	13.5	N/A	6
6	14.9	22.44	2.6	19.61	10.36	22.50	13.0	N/A	6
7	13.31	21.52	2.5	19.31	10.21	22.58	13.0	N/A	6
9	13.19	22.99	2.5	18.73	9.90	22.86	13.5	N/A	6
1	3.84 16.84	21.98 22.26	3.0	22.98	12.15	20.32	16.5	N/A	6
2	17.2	22.23	3.0	22.77	12.03	20.32	16.5	N/A	6
4	15.84	24.02	3.0	22.51	11.89	22.08	14.5	N/A	6
10	16.91	21.81	2.7	20.04	10.59	20.36	N/A	N/A	N/A
11	15.06	20.28	2.7	20.54	10.86	20.15	N/A	N/A	N/A
13	13.40*	22.67	2.7	20.12	10.63	21.05	N/A	N/A	N/A
8	13.45	21.38	3.0	13.52	7.146	21.42	16.25	2	2
1E	14.62	21.34	3.2	13.23	6.996	21.18	16.25	2	2
2E	19.53	21.09	3.2	13.86	7.326	20.96	16.5	2	2

* Plus coal bed weight from aborted test

DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA (5G-3)
NEW BUCK CAROLINA

Run Number	Burn Time (min)	Average Dilution Tunnel Measurements			Sample Data			
		Velocity (ft/sec)	Volumetric Flow Rate (dscf/min)	Temperature (^{o}R)	Total Sample Volume (dscf)		Particulate Catch (mg)	
					1	2	1	2
3	382	12.764	132.369	555.575	87.87	88.44	16.1	15.6
6	272	13.307	139.386	553.103	63.75	64.16	31.6	31.6
7	189	14.997	153.569	567.800	35.92	38.16	36.0	36.5
9	205	14.124	145.099	568.409	48.44	51.61	36.5	36.4
1	277	13.533	140.584	560.655	65.002	65.113	54.2	52.5
2	414	12.584	131.445	555.907	96.474	96.730	31.6	30.8
4	235	14.314	143.217	573.360	53.912	54.055	32.9	32.7
10	309	13.352	142.311	550.062	72.69	72.50	41.3	41.7
8	230	13.129	138.169	553.708	54.01	54.48	25.9	25.9
1E	164	13.651	141.679	557.444	38.20	37.90	44.2	43.1
2E	124	13.876	139.671	569.143	28.67	28.68	66.0	67.4

DILUTION TUNNEL DUAL TRAIN PRECISION NEW BUCK CAROLINA

Run Number	Sample Ratios		Total Emissions (grams)		% Deviation
	Train 1	Train 2	Train 1	Train 2	
3	575.47	571.77	9.265	8.920	1.58
6	594.70	590.87	18.793	18.672	.268
7	807.96	760.62	29.09	27.76	1.93
9	614.03	576.38	22.41	20.98	2.74
1	599.09	598.07	32.47	31.40	1.39
2	564.07	562.58	17.82	17.33	1.17
4	624.28	622.63	20.54	20.36	.363
10	604.96	606.51	24.985	25.291	.506
11	604.25	600.14	41.573	41.710	.137
13	700.44	706.33	14.359	17.729	8.727
8	588.38	583.31	15.239	15.11	.359
1E	608.22	613.14	26.883	26.436	.712
2E	604.10	603.84	39.871	40.699	.853

GENERAL SUMMARY OF RESULTS NEW BUCK CAROLINA

Run Number	Burn Rate (kg/hr)	Change In Surface Temperature (^{o}F)	Initial Draft (in. H_2O)	Primary Air Setting	Run Time (min)	Average Draft (in. H_2O)
3	1.14	7.6	.054	5 cm	382	.057
6	1.60	57.8	.063	4 cm	272	.067
7	2.28	30.4	.075	full open	189	.080
9	2.03	2.8	.072	full open	205	.077
1	1.85	44.4	.067	3.5 cm	277	.069
2	1.22	4.0	.054	4.5 cm	414	.061
4	2.13	27.6	.072	full open	235	.075
10	1.44	1	.052	4 cm	309	.058
11	1.22	23.04	.049	4.7 cm	375	.054
13	1.87	15.60	.063	full open	240	.072
8	1.31	17.2	.058	5 cm	230	.059
1E	1.827	16.6	.063	3.7 cm	164	.063
2E	2.515	35.8	.070	full open	124	.070

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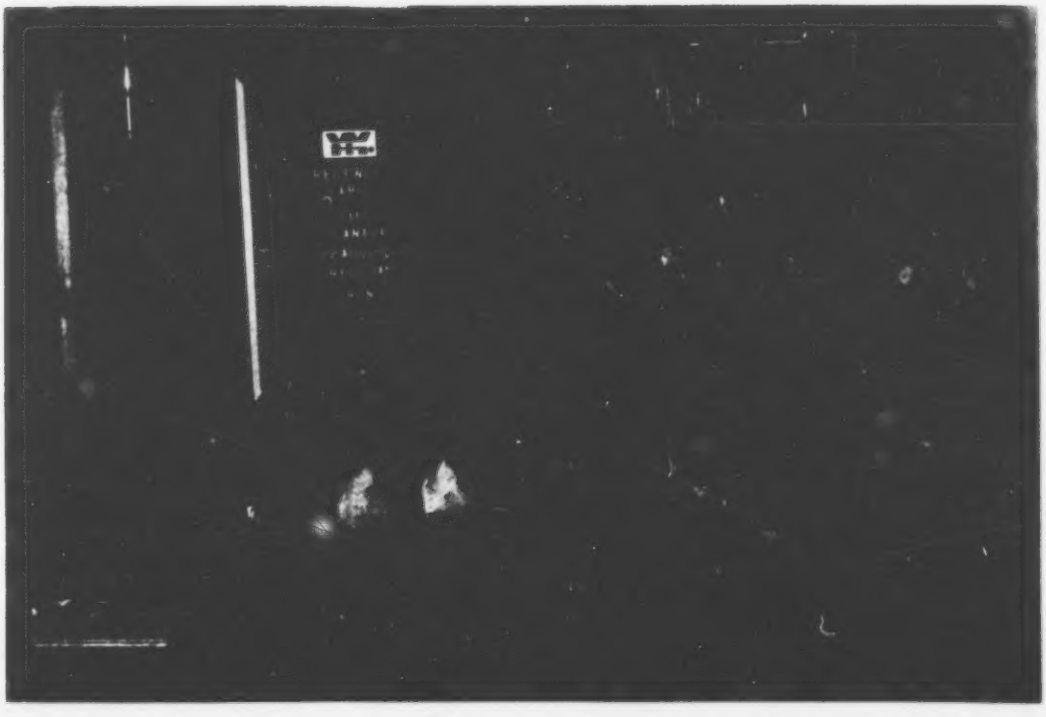

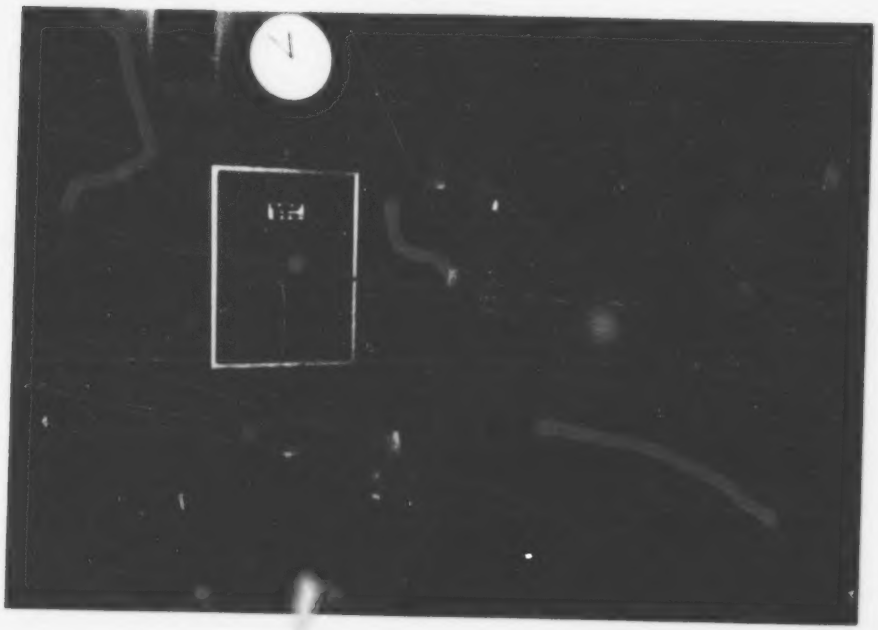

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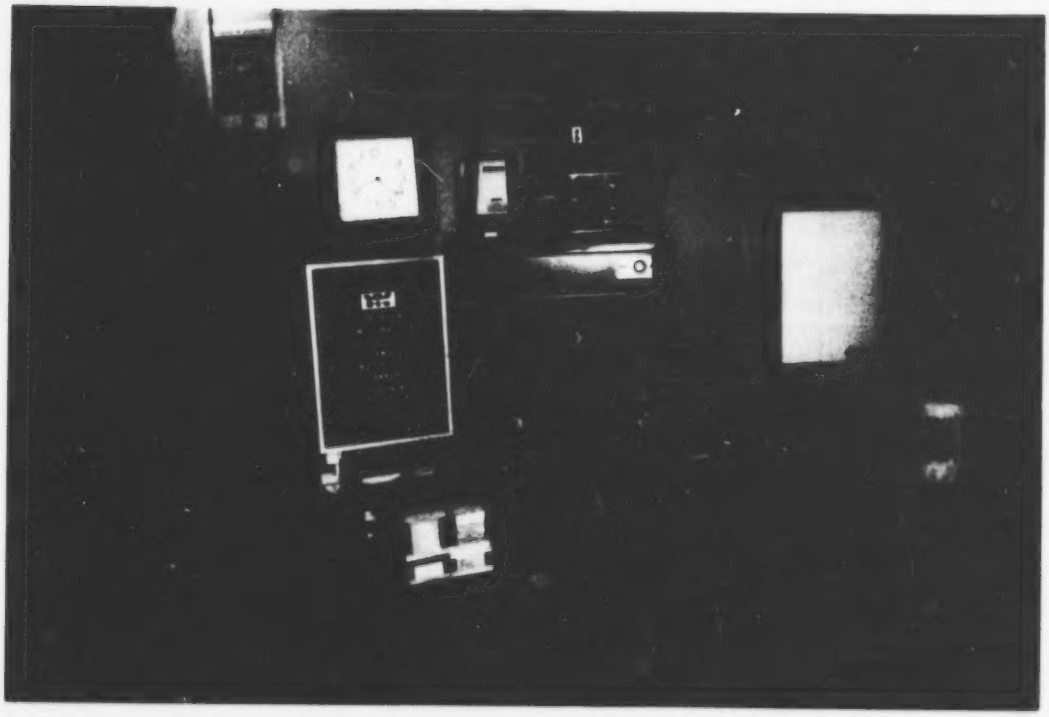

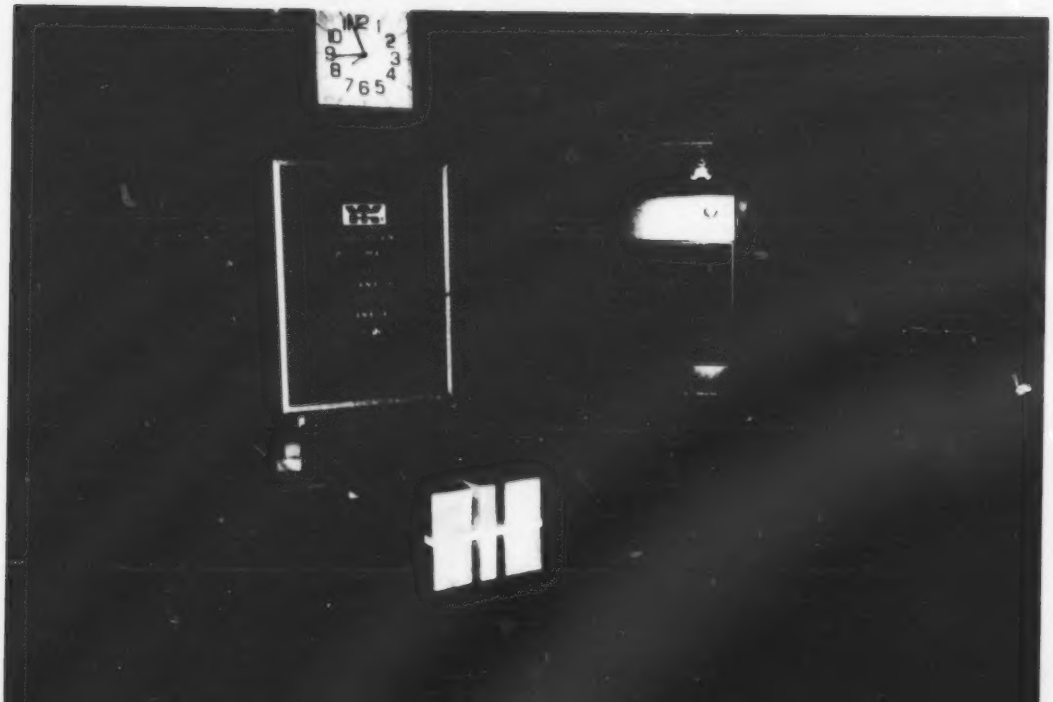
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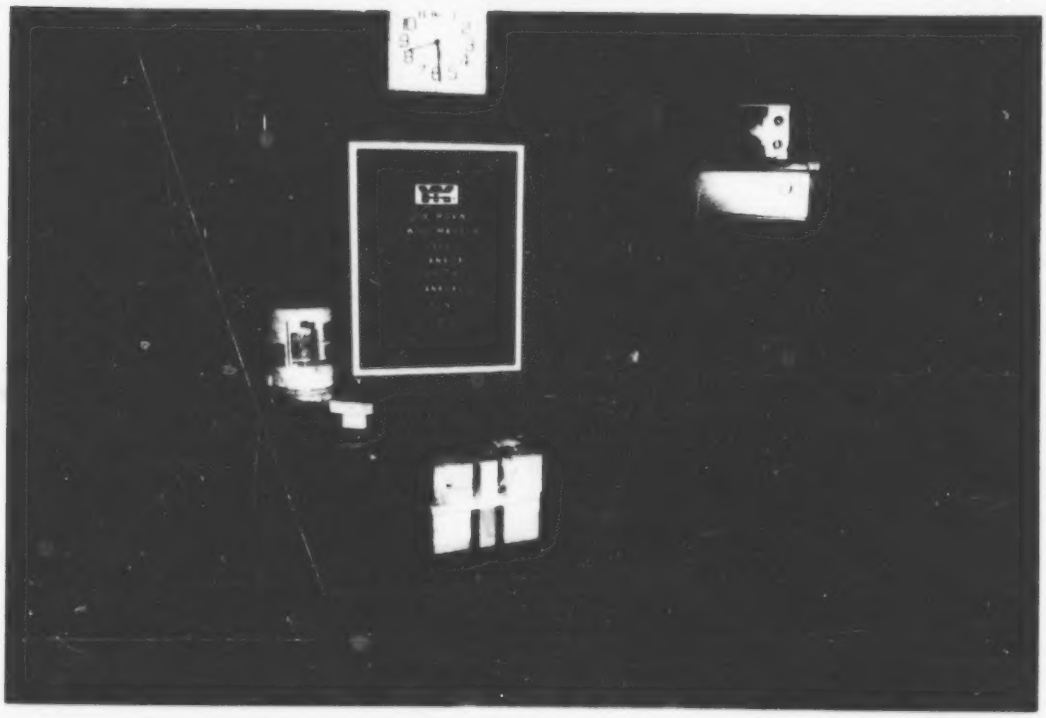

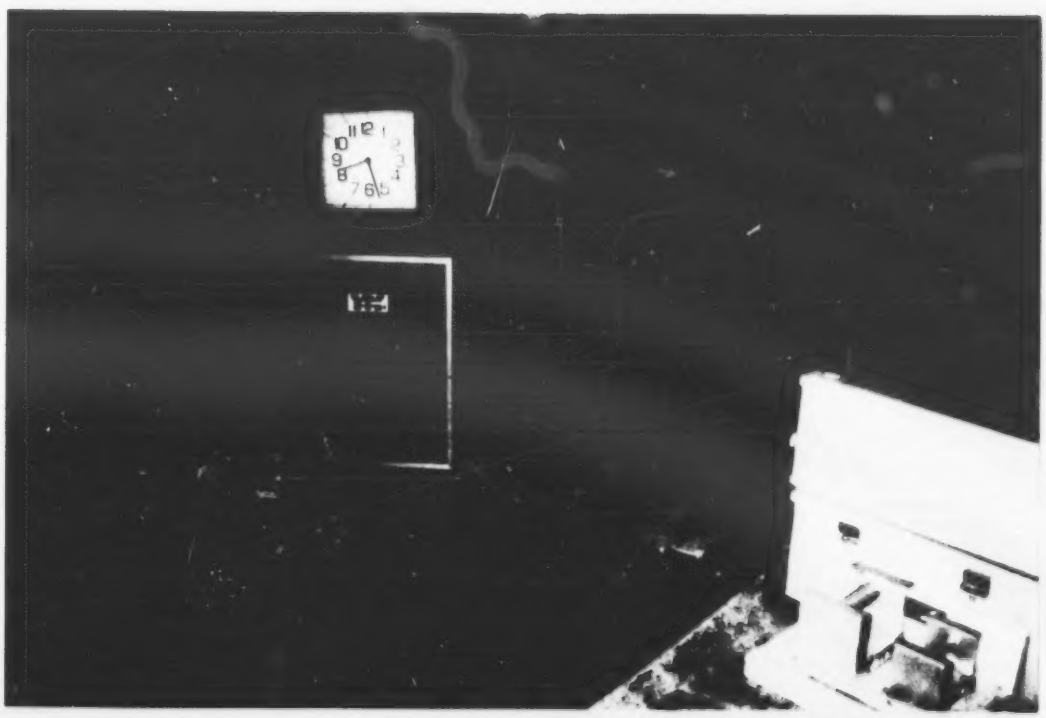

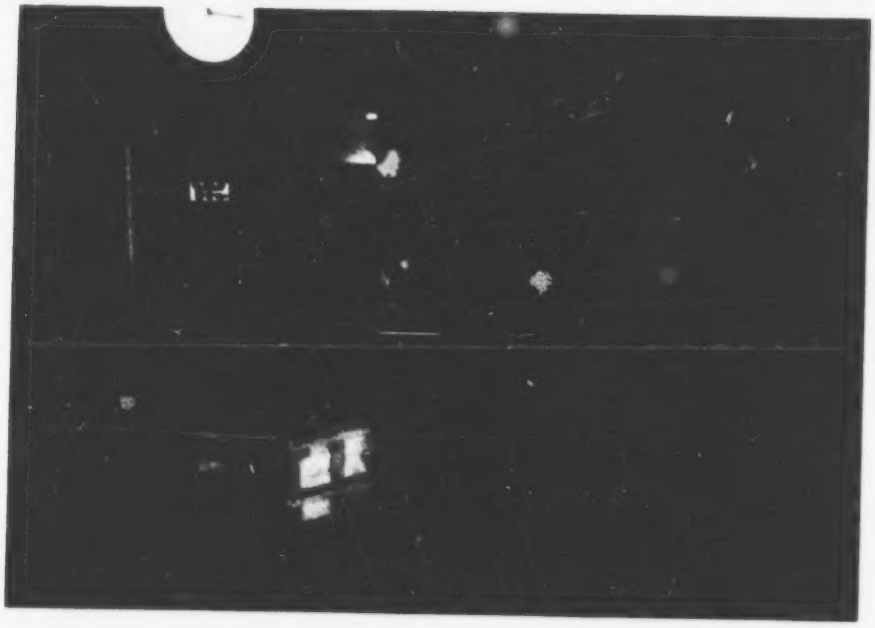

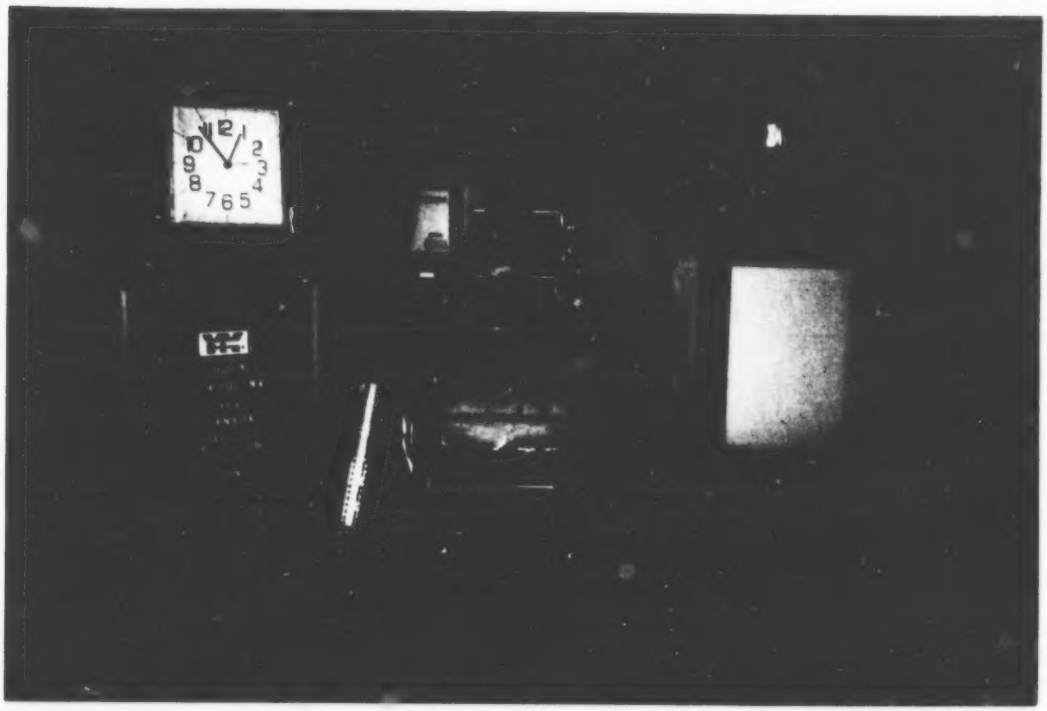

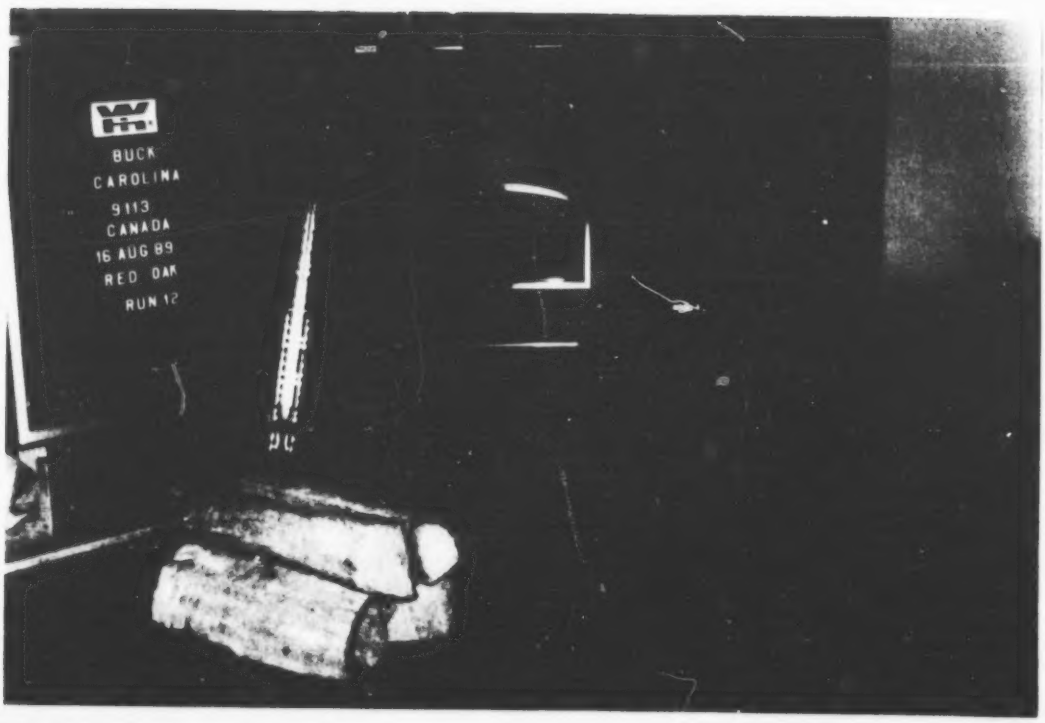
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